Technology Review

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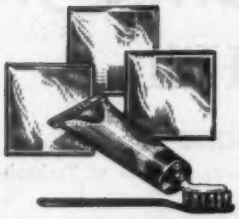

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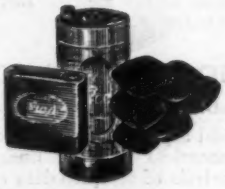

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By Wilbur B. Davenport, Jr. and William L. Root, Massachusetts Institute of Technology. *Lincoln Laboratory Publications.* 393 pages, $11.00.

An *introduction* to the statistical *theory* underlying a study of signals and noises in communications systems. Emphasis is placed on techniques as well as results. Parts of probability theory and the modern theory of random processes are developed in a way suitable for an engineering reader. This material is applied to give a coherent treatment of many basic communications engineering noise problems. The chief departure in treatment is the replacing of various *ad hoc* methods of treating random signals and noise by a *consistent set of methods from the theory of random processes.*

AN INTRODUCTION TO STATISTICAL COMMUNICATION THEORY

By David Middleton. *McGraw-Hill International Series in Pure and Applied Physics.* 1140 pages, $25.00

Covers important mathematical aspects of large-scale, complex automatic control systems. Discusses feedback theory; matrix methods; numerical analysis; linear integral equations; basic statistical theory; systems analyses in phase space; analysis of sampled-data systems; and much more.

INFORMATION TRANSMISSION, MODULATION AND NOISE

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By Mischa Schwartz, Polytechnic Institute of Brooklyn. *McGraw-Hill Electrical and Electronic Engineering Series. Brooklyn Polytechnic Institute Series.* 454 pages, $11.00.

A senior or first-year graduate level text which stresses the basic unity inherent in modern information transmission of information—non-zero time response or finite bandwidth and noise. The significance of these two limitations is explored in a representative group of modulation systems. There are approximately 250 problems ranging from simple numerical exercises to detailed step-by-step problems which extend the material in the text.

MISSILE AERODYNAMICS

By Jack N. Nielsen, VIDYA, Inc. *McGraw-Hill Series in Missile and Space Technology.* 450 pages, $12.50

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GAS PURIFICATION

By Arthur L. Kohl and Fred C. Riesenfeld, both of the Fluor Corporation, Ltd. *McGraw-Hill Series in Chemical Engineering.* 556 pages, $15.00

This book provides a practical engineering description of techniques and processes which are widespread in use. Subject matter is limited to the removal from gas streams of gas-phase impurities which are present in relatively minor proportions. Space has been allocated on the basis of apparent importance to industry with greatest stress on those processes which are common to more than one field.

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Technology Review

Reg. U.S. Pat. Off.

Volume 62, Number 6 *Edited at the Massachusetts Institute of Technology* *April, 1960*

Feedback

Recommended Reading

FROM W. D. WOLFE, '27:

After several readings of Dr. Wiener's "The Duty of the Intellectual" in the February, 1960, Technology Review, I'm impelled to write some sort of approval of this remarkable article. I think it's tops! It should be made required reading and study for budding intellectuals. Hail to Dr. Wiener's incisive candor!

Cuyahoga Falls, Ohio

A Problem Deflector

FROM B. C. OELHEIM, '46:

I was excited when reading the article on education in the last issue to reach me, and have shown it to our two teachers from England who are teaching about 20 American children in seven of the first eight grades in one room.

We are a group of about 200 Americans situated in a small Spanish community. We are learning to live with our most courteous hosts and for all of us it is a worthwhile experience we shall never forget.

An idea which I pass along to you is suggested by a weather-vane type wind deflector which I have placed on top of our chimney, and which permits us to use our fireplace, today, in a very high wind. (Without the deflector we would have hot ashes blown all over our living room.) I wish that all of us might employ a similar deflector for all of our problems in life and accept each new problem as an incentive to our thinking and as a challenge to our inventive genius. Why can't we use all of our atomic waste material just as fast as it accumulates?

U.S. Naval Activities,
Cartagena, Spain

Helpful to a School

FROM MRS. GUI IGNON:

Today, as in the past, this library would like to express its wholehearted appreciation of your publication. The Technology Review serves as a most valuable and constantly used reference source for the students and faculty, both during the regular academic year, and also during the summer session for advanced science courses.

The Thacher School
Ojai, Ventura County, Calif.

EDITOR: Volta Torrey; BUSINESS MANAGER: R. T. Jope,'28; CIRCULATION MANAGER: D. P. Severance,'38; EDITORIAL ASSOCIATES: J. J. Rowlands, Francis E. Wylie, John I. Mattill; EDITORIAL STAFF: Ruth King, Diana de Filippi; BUSINESS STAFF: Madeline R. McCormick, Louise E. Ryan; PUBLISHER: H. E. Lobdell,'17.

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This Month

The Cover

The picture on the cover was provided by the Boston Museum of Fine Arts. How the suspicions that it was a forgery were verified by an electron microbeam probe is related in the article on page 25.

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Personal news of especial interest to the Alumni of M.I.T.

The Trend of Affairs 17
Another Compton Lecture series is announced, 1960 class reunions are listed, and other items reported.

The Morale of Freshmen 22
John I. Mattill summarizes findings in a psychological study of the Class of 1961 during its first year.

The Story Behind Polaris 24
A brief report on Alumni in the M.I.T. Instrumentation Laboratory.

The Lady Is a Phony 25
How a graduate student's work aided the Boston Museum of Fine Arts.

Factors in Scientific Strength 29
An excerpt from the talk given in Australia by James R. Killian, Jr., '26, Chairman of the Corporation.

Antibodies Seen With Electrons 32
The electron microscope produces pictures of important molecules.

Tomorrow's Hot Ashes 33
Rolf Eliassen, '32, explains the disposal of radioactive wastes.

Elements of Instruments 36
Professor Kurt S. Lion describes an educational opportunity.

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Items that were news 25, 50, 75, and 99 years ago at M.I.T.

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Individuals Noteworthy

7th Webster Professor

ERNST A. GUILLEMIN, '24, was designated this spring to be the seventh Webster Professor of Electrical Engineering at M.I.T.

The Webster Professorship was established by a $400,000 grant to the Institute from the Edwin Sibley Webster Foundation, and was the first endowed chair in the Department of Electrical Engineering. Mr. Webster, '88, was the 16th President of the Alumni Association, and long an active member of the M.I.T. Corporation.

Professor Guillemin came to M.I.T. from the University of Wisconsin, and later received his doctorate from the University of Munich. He was an assistant and instructor in the Electrical Engineering Department before becoming an assistant professor in 1928, an associate professor in 1936, and professor of electrical communications in 1944. He was a general consultant to the Radiation Laboratory from 1940 to 1945. He is a Fellow of the American Institute of Electrical Engineers, and the author of *Introductory Circuit Theory* (John Wiley and Sons, Inc., 1953).

Ernst A. Guillemin, '24

New Posts

NAMED in the news recently were the Alumni whose elections, promotions, and appointments are recorded below:

George W. Ousler, '16, as Assistant to the President, Edwin L. Wiegand Company, Pittsburgh, Pa. . . . *Robert E. Wilson, '16,* as a Member of the United States Atomic Energy Commission . . . *John J. Healy, Jr., '21,* as Vice-president, American Institute of Chemical Engineers;

Howard E. Whitaker, '24, as President, American Paper and Pulp Association . . . *Duncan A. Crawford, '26,* as President, Atlanta Gas Light Company . . . *Elton E. Staples, '26,* as President, Hevi-Duty Electric Company, division of Basic Products Corporation . . . *C. Wesley Meytrott, '27,* as President, the Adelphi Academy of Brooklyn;

By the General Electric Company: *Harland P. Sisk, '27,* as Plant Manager, Holyoke, Mass. . . . *J. Herbert Hollomon, '40,* as Head, General Engineering Laboratory . . . *James E. S. Warden, '40,* as Manager of Operation, West Milton Site Facilities, Knolls Atomic Power Laboratory . . . *Donald D. Scarff, '41,* as General Manager, Large Lamp Department . . . *Bernard F. Cassidy, '52,* as Manager, DIG Power Plant Engineering-Electrical;

Myron T. Smith, '30, as Director of Sales, General Radio Company . . . *Thomas W. Hafer, '35,* and *Edmond P. DiGiannantonio, '40,* respectively, as Manager-Corporate Manufacturing Engineering, and as Marketing Manager, Submarine Signal Operations, Raytheon Company;

Morton M. Jenkins, '35, as Assistant to the Manager of Steel Sales, A. M. Byers Company . . . *William J. Suchors, '35,* as Coordinating Director, Engineering and Product Planning, Remington Rand Univac Division, Sperry Rand Corporation . . . *William M. Creasy, '36,* as Manager, the New York Division, The Lummus Company;

James McCormack, '37, as a Director, Bulova Watch Company, Inc. . . . *Robert R. Wagstaff, '37,* as Engineering Vice-president and Director, United Engineers & Constructors, Inc., Philadelphia . . . *August B. Huniche, '39,* as Director of Engineering, Cramer Controls Corporation . . . *Harlow J. Reed, '39,* as Vice-president for Engineering, Olin Mathieson Chemical Corporation;

Richard L. Pope, '40, John G. Holmes, '47, and *William W. Heilman, '51,* respectively, as Manager, Marketing Research Division, as Manager, Central Sales Region, and as Plant Manager, Niagara Plant, Union Carbide Metals Company;

Herman A. Affel, Jr., '41, as General Manager, Computer Division, Philco Corporation . . . *Robert T. Luedeman, '41,* as Chief Engineer, Materials, Weston Instruments Division, Daystrom, Inc. . . . *James D. McNitt, '41,* as Executive Vice-president, Bristol Laboratories;

Charles A. Hathaway, '43, as Assistant General Manager, Air Impeller Division, Torrington Manufacturing Company . . . *John M. Waters, '44,* as Director of Administrative Services, Plax Corporation, Hartford, Conn. . . . *David W. Brown, '48,* as Manager of European Operations, Blackhawk, S.A.;

George F. Clifford, '48, as Manager, Spinco Division, Beckman Instruments, Inc., Palo Alto, Calif. . . . *Sidney Lees, '48,* as President and Technical Director, Instrument Research, Inc., Washington, D.C. . . . *Harold G. Ingraham, Jr., '49,* as Assistant Actuary, Ordinary, Massachusetts Mutual Life Insurance Company;

Robert M. White, '49, as Associate Director of Research, The Travelers Weather Research Center, Hartford . . . *Daniel L. McGuinness, Jr., '50,* as Vice-president, Proportioneers, Inc., division of B-I-F Industries, Inc., Providence, R.I. . . . *Ralph L. Quinlan, '50,* as Development Manager, Goodyear Tire & Rubber Company, Windsor, Vt.;

Kenneth W. Gardiner, '53, as Chief Research Chemist, Consolidated Electrodynamics Corporation, subsidiary of Bell & Howell Company . . . *Richard J. Wengraf, '53,* as Resident City Planner, New Bedford, Mass.

(Continued on page 6)

. . . a hand in things to come

Creating a strange world of cold

The coldest natural temperature ever recorded—100 degrees below zero—occurred in the Antarctic. But the people of Union Carbide are producing temperatures all the way down to minus 450 degrees . . . approaching absolute zero!

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Individuals Noteworthy

(Continued from page 4)

Management Academy

PROFESSOR Emeritus Erwin H. Schell, '12, of the M.I.T. School of Industrial Management, was a delegate to the International Academy of Management's meeting in Australia, which was addressed by James R. Killian, Jr., '26, Chairman of the M.I.T. Corporation. Fifteen hundred representatives of 29 nations were expected to attend this 12th meeting of the *Comité International de l'Organisation Scientifique*, known as CIOS.

Professor Schell is chancellor of the International Academy of Management, an honorary society formed in 1957, and was to participate in ceremonies honoring international managers. The Academy recognizes contributions to management through work, vision, values, and beliefs in a free society by selecting 10 Fellows each year. He also was invited to speak at the University of Melbourne.

Librarian Emeritus

ALTHOUGH Miss Marguerite Chamberlain's retirement is reported in the M.I.T. librarian's annual report, she is still working at the Institute part time, and concerning herself especially with the enlargement of the mathematics collection.

Miss Chamberlain came to M.I.T. to organize the science library in March, 1932. She says now that she has organized it she spends her time "trying to keep up with it." In the early days, she recalls, the Institute was small enough so that a librarian knew everyone who patronized the library and what he did. In May, 1952, Miss Chamberlain, along with the science library, moved from the Eastman Library in Building 6 to the new Hayden building. "There's much more movement and bustling about here," she says. "In fact it's a bit like doing business on Main Street."

After graduating from Colby College in Maine with a B.A. degree, Miss Chamberlain taught for three years before continuing her studies at Simmons, held various library posts, and finally came to M.I.T.

(Continued on page 12)

OPTIC NERVE FOR EYES THAT SEE 100 FEET BELOW THE SURFACE

This is a television camera. Its job is to photograph the substrata of excavations, thereby providing information needed by engineers in planning the construction of Boston's new Prudential Center, a modern, multi-million dollar real estate development.

Here in the Back Bay section of Boston, with its artificially maintained water table, this sealed camera must go down into a water-filled hole 100 feet below the surface. To transmit the picture from the camera to the surface monitor, Lake Service Corp. of Brighton, Massachusetts, designers and manufacturers of the television equipment, chose Simplex Anhydrex XX insulated cable because of its ability to withstand the rigors of submarine and direct burial duty.

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ADVANCED CONFIGURATION DESIGN — **WICHITA AREA**

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INFRARED — **SEATTLE AREA**

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ELECTRONICS-RELIABILITY — **SEATTLE AREA**

Electrical engineer with B.S. degree minimum (graduate work or equivalent experience desired) to organize and manage reliability programs; to establish requirements, evaluate reliability data and initiate corrective action for missile components and tactical test equipment.

ELECTRONICS-DIGITAL COMPUTER — **SEATTLE AREA**

Engineers with advanced E.E. degree or particularly applicable experience to design and integrate digital computers in advanced military and space programs, involving internal logic design of the computers and the external organization of the associated equipment used in the guidance and control system.

ENGINEERING ANALYSIS & PROGRAMMING — **SEATTLE**

Mathematicians or engineers with B.S. to Ph.D. degrees to work in engineering computing and analysis areas. Analysis positions involve correlation and conversion matrix studies, trajectory simulation programs, error analysis and simulation studies and many others. Computing positions involve programming a wide variety of complex engineering problems to be solved with high-speed electronic data processing machines—digital and analog.

PLASMA PHYSICS — **SEATTLE AREA**

Experimental physicist with Ph.D. in physics for the staff of the Plasma Physics Laboratory, Boeing Scientific Research Laboratories, to conduct studies in the field of Basic Experimental Micro Wave Plasma Physics, Basic Transport Properties of Plasmas and in Theoretical and Experimental Quantum Plasma Physics.

OPERATIONS & WEAPONS SYSTEMS ANALYSIS — **WICHITA**

M.S. or Ph.D. in math, physics, electrical or aeronautical engineering to obtain data on the anticipated operational environment of the devices under study by Advanced Design Staff. Devise analytical models of procedures describing operation of the devices in order to estimate the operational utility of same under study. Studies compare Advanced Design products with other companies and demonstrate anticipated utility to the customer.

ELECTRONICS-TELEMETRY — **SEATTLE AREA**

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ELECTRO-MAGNETICS — **SEATTLE AREA**

Ph.D. in electrical engineering or physics to direct and participate in the work of a research group engaged in the theoretical and experimental investigation of the propagation and reflection of electro-magnetic waves in the presence of a plasma.

WELDING ENGINEERING — **SEATTLE AREA**

Engineers with degree in Met.E., Mech.E., E.E. or equivalent, to maintain weld equipment, design tools, develop techniques and direct proper use of this equipment, and establish processes for all types of welds used in the unit, including weld settings for qualification programs.

PERFORMANCE & STABILITY & CONTROL ANALYSIS — **SEATTLE AREA**

Aeronautical engineers at B.S. and M.S. level to conduct performance analysis and stability and control analysis. Each field is intimately associated with flight testing and wind tunnel testing. Performance assignments include preparation of sales presentations, operating instructions and preliminary design work in connection with new aircraft; stability and control assignments cover wing and tail design as well as studies concerning detailed control systems.

GEOASTROPHYSICS — **SEATTLE AREA**

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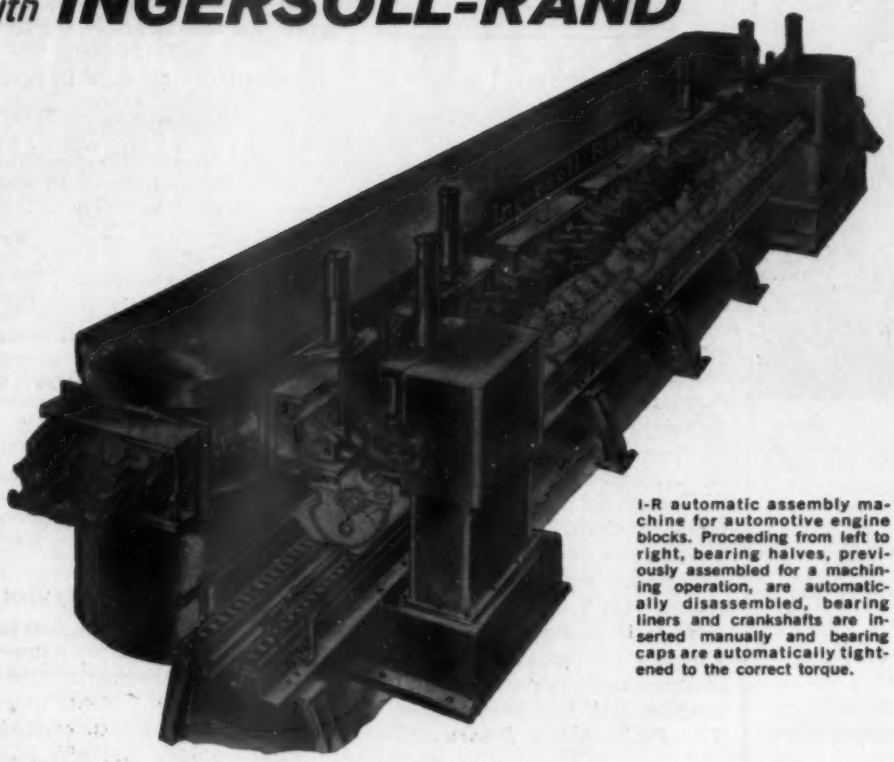

I-R automatic assembly machine for automotive engine blocks. Proceeding from left to right, bearing halves, previously assembled for a machining operation, are automatically disassembled, bearing liners and crankshafts are inserted manually and bearing caps are automatically tightened to the correct torque.

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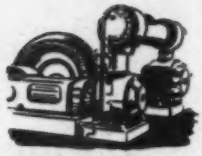

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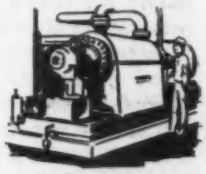

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The Air Force THOR, built by Douglas and three associate prime contractors, shows how well a down-to-earth approach to outer space can work. Since its first shoot in 1957, it has had more than *fifty* successful launchings... at a variety of jobs from re-entry vehicle testing at ICBM ranges to placing satellites in orbit.

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Individuals Noteworthy

(Continued from page 6)

New Philosopher

JOHN RAWLS, whose special field is moral and political philosophy, has been appointed professor of humanities at M.I.T., effective next July 1.

Born in Baltimore in 1921, Dr. Rawls received both his undergraduate and graduate education at Princeton University, and became an instructor in philosophy there. In addition to several fellowships, he received a post-doctoral Fulbright research grant in 1952 for a year at Oxford, and in 1956 he received a research grant from the Rockefeller Foundation. He went to Cornell as an assistant professor in 1953 and three years later he was made an associate professor. This year he has been on leave to lecture at Harvard. He is a member of the Advisory Council of Princeton's Department of Philosophy and has been editor of *The Philosophical Review*.

Honors

MEDALISTS and recent recipients of other distinctions include:

Milton Kahn, '12, establishment of the Milton Kahn Chair in Community Organization, by Brandeis University . . . *Albert Haertlein, '18,* the Award of Merit, by the Engineering Societies of New England . . . *Edwin T. Steffian, '21,* the Residential Citation, of its Seventh Annual Design Awards Program, by *Progressive Architecture;*

Stanley D. Stookey, '40, the first patent for invention of Pyroceram glass-ceramic materials . . . *Lt. Colonel Woodruff T. Sullivan, '40,* the Legion of Merit, by the Secretary of the Air Force . . . *Lt. Colonel Nils M. Bengtson, '48,* the Commendation Ribbon, U.S. Army.

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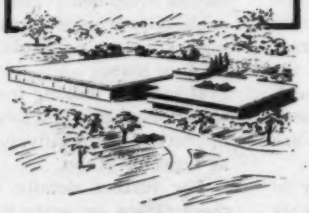

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Honored by Newcomen

A BOOK of more than 65 patents bearing the name of David A. Meeker, '24, President of the Hobart Manufacturing Company, was presented to Mr. Meeker at a dinner in Dayton on February 10, given in his honor by the Newcomen Society in North America.

At the same time, Mr. Meeker received a congratulatory letter from the U.S. Commissioner of Patents — and the title of Colonel from the Governor of Kentucky. M.I.T. Alumni among the 450 business and industrial leaders present included Abbott L. Johnson, 2d, '22, Joseph C. Patty, '22, Edward S. Johnston, '25, and Guy S. Frisbie, '26.

Alumni Committees

AT ITS February meeting, the Alumni Council elected D. Reid Weedon, Jr., '41, as chairman of the Association's Committee on M.I.T.'s Centennial. Other new committees include:

Future Subsidies for Alumni Day and Reunions — Hugh S. Ferguson, '23, chairman; Ralph H. Davis, '31, F. Leroy Foster, '25, and Philip A. Stoddard, '40.

Continuing Education for Alumni — Carroll L. Wilson, '32, chairman; James M. Austin, '41, Charles C. Bell, '33, Donald A. Hurter, '46, Douglas M. McGregor, Ascher H. Shapiro, '38, Thomas K. Sherwood, '24, Samuel R. Spiker, '25, and Theos J. Thompson.

Local Clubs and Activities — Clarence R. Westaway, '33, chairman; William S. Edgerly, '49, George H. R. McQueen, '49, Louis Rosenblum, '42, Elwood W. Schafer, '32, Paul P. Shepherd, '53, and John T. Weaver, '50.

(Concluded on page 50)

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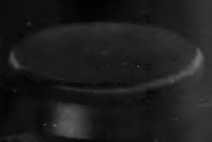

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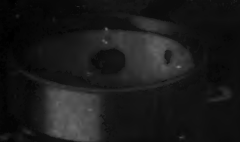

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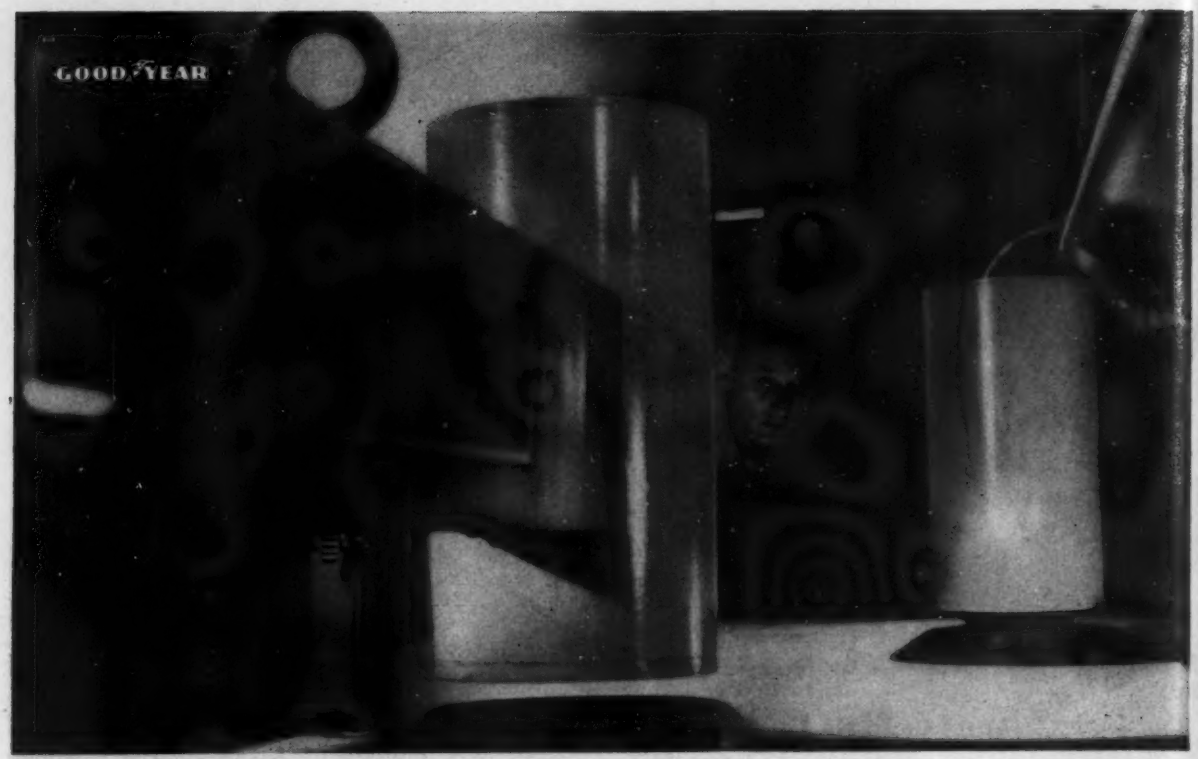

Seeing eyes—Nuclear energy activates these two detector heads to measure thickness of rubber compound as it is applied to Goodyear's 3-T Cord. This is one of the new electronic quality controls which help produce the whisper-quiet, cushion-soft, longer and safer mileage you get from Turnpike-Proved tires by Goodyear.

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2. New whisper-quiet, cushion-soft ride. New chemicals permit us to soften the tread of our tires *without sacrificing mileage*. Because we have rubber that's softer, yet tougher, Goodyear tires now give you up to 25% *more* safe mileage than before.

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Without question, these Goodyear tires are the finest we've ever produced. Goodyear, Akron 16, Ohio.

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Trend Of Affairs

Four Compton Lectures On Biological Order

A SERIES of Karl Taylor Compton lectures will be given at M.I.T. this spring by André Lwoff, Head of the Department of Microbial-physiology at the Pasteur Institute in Paris. Dr. Lwoff has long been a leader among scientists interested in the unity of biochemical phenomena, and "Biological Order" will be the theme of his four lectures here in April.

Born in France in 1902 and educated at the University of Paris, he has been associated with the Pasteur Institute for nearly 40 years. After becoming an authority on protozoa, he turned to microbial nutrition and bacterial physiology; more recently he has been studying viruses in tissue cultures of vertebrate cells and the problems of genetic control.

In his own words: "Dr. Lwoff has worked here and there on this and that . . . has been a fellow of the Rockefeller Foundation at Heidelberg and at Cambridge and Dunham Lecturer at Harvard . . . has discovered some strange creatures and unexpected phenomena which have been published in 250 papers dealing with various aspects of microbiology . . . (and) as a result of that and this, is now a member of various scientific societies, here and there."

These societies include the National Academy of Sciences in this country, the New York Academy of Sciences, the Botanical Society of America, the American Academy of Arts and Sciences, the Harvey Society, and the Royal Society of London. He has visited this and other English-speaking countries frequently, and last year received honorary degrees from both the University of Oxford and the University of Chicago.

"In his lectures," an acquaintance reports, "he naturally tends to put philosophical constructions into what others would leave as uninterrupted data. He has a whimsical humor which delights audiences and enlivens otherwise technically difficult discussions."

At the Institute he will discuss:

On April 6 — "The Living System: Biological Order and Entropy."

On April 12 — "Hereditary Order: Specificity, Genetic Information, and Nucleic Acids."

On April 14—"Functional Order: Control and Regulation of Biosyntheses."

On April 20 — "Disorder: Viruses and Viral Functions."

Each lecture will be at 8 P.M. in Kresge Auditorium.

On April 15, at 4 P.M., Professor Cyrus Levinthal of M.I.T. will be chairman of a seminar on "Topology and Topography of the Gene," at which Dr. Lwoff and Professor Seymour Benzer of Purdue University will speak; and on April 22, at 4 P.M., Dr. Salvador E. Luria of M.I.T. will preside at a seminar on "Viruses and Cellular Control Mechanisms," in which Dr. Lwoff will be joined by Professor Renato Dulbecco of the California Institute of Technology.

Pioneering in Aviation

IN 1912 Igor I. Sikorsky built a four-place biplane with a wood veneer fuselage and won a prize of 30,000 rubles from the Russian government. A year later his four-engine biplane, which had such unusual features as upholstered chairs and a lavatory, set a world's record by carrying 54 people; the Czar inspected it, but did not take a ride.

These were some of the early exploits of the aeronautical engineer who will deliver the second Lester D. Gardner lecture at M.I.T. on "Pioneering in Aviation." The lecture, at 3:30 P.M. on Thursday, April 14, in the Kresge Little Theater, will be open to the public.

Mr. Sikorsky founded a company in 1923 to build flying boats and helicopters in this country. His honors include the Potts Medal of the Franklin Institute, the Sylvanus Reed Award, the Guggenheim Medal, the Collier Trophy, and the James Watt International Medal; France recently made him a Chevalier of the Legion of Honor.

The Gardner lectures result from a bequest of the late Major Lester D. Gardner, '98, who for many years was publisher of *Aviation* and *Aeronautical Engineering* magazines.

International Week

FOREIGN students at the Institute gave a series of programs in March to express their appreciation to America. In addition to a discussion of "Underdeveloped Countries — A Threat to World Peace" the events scheduled included film showings, a performance of native African dances, and demonstrations of cricket, judo and jujitsu, and "Kabaddi," a ball game played in India that is rarely seen in the United States. The chairman of the committee in charge was Jaime H. de Sola, '60, who is from Curacao.

Class Reunions in 1960

1905 June 10–12. Cape Cod. William G. Ball, Reunion Chairman, Box 285, Cotuit, Mass.

1907 June 8–10. Oyster Harbors Club, Osterville, Mass. Philip B. Walker, Secretary, 18 Summit Street, Whitinsville.

1908 June 10–12. Melrose Inn, Harwich Port, Mass. H. Leston Carter, Secretary, 14 Roslyn Road, Waban 68.

1910 June 10–12. *50th reunion:* Charterhouse Motor Hotel, Waltham, Mass. John B. Babcock, Reunion Chairman, Box 1981, Portland, Maine.

1915 June 10–12. Snow Inn, Harwich Port, Mass. Reunion Chairmen: Azel W. Mack, Apt. 26A, 100 Memorial Drive, Cambridge 42; George T. Rooney, 10 Sharpe Road, Belmont 78.

1920 June 10–12. Chatham Bars Inn, Chatham, Mass. Malcolm S. Burroughs, Reunion Chairman, The Dexter Company, 219 East 44th Street, New York 17, N.Y.

1925 June 10–12. Chatham Bars Inn, Chatham, Mass. Reunion Chairmen: David Goldman, 59 Littlefield Road, Newton 59; Edwin E. Kussmaul, 74 Highview Street, Westwood.

1930 June 10–12. Oyster Harbors Club, Osterville, Mass. Reunion Chairmen: Edwin M. Kingsley, 14 Upwey Road, Wellesley Hills 82; George W. Gassett, 31 Liberty Pole Road, Hingham.

1935 June 10–12. *25th reunion:* Baker House, M.I.T., Cambridge 39. Professor Walter H. Stockmayer, Reunion Chairman, Room 6-229, M.I.T., Cambridge 39.

1940 June 10–12. Chatham Bars Inn, Chatham, Mass. Robert A. Bittenbender, Reunion Chairman, 85 Meriam Street, Lexington.

1945 June 10–12. Snow Inn, Harwich Port, Mass. Reunion Chairmen: William J. McKay, 6 Robert Road, Framingham; Gerald V. Quinnan, 210 May Street, Needham.

1950 June 10–12. The Curtis Hotel, Lenox, Mass. Reunion Chairmen: Frank E. Parisi, 53 East Quinobequin Road, Waban 68; Charles Levy, 61 Central Street, Auburndale 66.

1955 June 11–12. *5th reunion.* Woodbound Inn, Rindge, N.H. Reunion Chairmen: Lennard Wharton, 19 Shepard Street, Cambridge 38; James H. Eacker, Eliot Street, Sherborn, Mass.

THESE SIX LADIES spend 45 minutes of every working hour in a darkened room "reading" photographs showing tracks of atomic particles for the M.I.T. Laboratory for Nuclear Science. Last year they examined 100,000 pictures for the physicists. Head of the group (*standing in picture above*) is Mrs. Marianne Von Randow from Germany. She studied mathematics at the University of Hamburg and is the only one with scientific training. From left to right (in picture with Mrs. Von Randow) are Ragnhild Reinert from Norway, Mrs. Guela Pariser from Israel, and Grace Dutot from Tamaqua, Pa.; in the other photo are Andree Pellegrin from France and Mrs. Ameriga Milano from Rome.

Telephoning Via a Balloon

ON FEBRUARY 27, a bright new "star" shown briefly in the early evening sky, visible for hundreds of miles up and down the Atlantic Coast. This transient celestial visitor was a 100-foot aluminized balloon, rocket-launched from Wallops Island, Va., by the National Aeronautics and Space Administration. The rocket hurled the balloon, folded into a 26-inch container, into a sub-orbital trajectory up to an altitude of about 100 nautical miles, where it inflated and continued upward, to a maximum height of some 200 miles before falling back to earth.

Time exposure made at Round Hill shows bright balloon trail and (right) the trace from rocket burnout. Clouds and timing marker caused breaks in line.

Its brilliant glow in the rays of the sun from beyond the western horizon, outshining all normal residents of the heavens, heralded a new step forward in radio communications, for this was the first time on record that a man's voice was reflected back to earth from an artificial neighbor of terrestrial origin. FM radio voice messages reflected from the balloon were fully received at M.I.T.'s Round Hill field station in South Dartmouth, Mass., by members of Lincoln Laboratory's Radio Propagation Group co-operating with Bell Telephone Laboratories, which is under contract with NASA.

Tracking the balloon with radars at 425 and 675 megacycles per second, not to mention a photo-theodite and an optical tracker, the Lincoln team pointed a parabolic receiving antenna at the target and recorded a voice message from Holmdel, N.J., about 300 air-line miles away. The radio wave path length in this test varied between 500 and 1000 miles.

Between transmissions of the voice message, two corner antennas mounted on the 28-foot dish were used to measure signal fading (which might tell how well the balloon had inflated). In a similar experiment on January 16, a radio carrier signal was bounced from Holmdel to Round Hill but voice modulation was not attempted.

Lincoln's Air Force-sponsored radar on Millstone Hill tracked the launching rocket and the balloon as it passed through apogee and came back to earth in February. The Millstone data, transmitted to NASA for evaluation, showed that the balloon slowed abruptly in its descent at an altitude of about 40 nautical miles, and dropped much slower from there on.

This successful experiment was another step by the NASA-directed team toward long-range, wide-band radio relay communication by means of passive satellites, which do not need electronics or power of their own, but are large enough to reflect back to earth a radio signal of useful magnitude.

Called Project Echo, the aim of this research project is to use balloon satellites in high orbits, apparently almost stationary in the sky, as targets for long-range radio relay.

This computer display shows averaged radar data at Millstone Hill on balloon. Horizontal time scale covers about 15 minutes. Curves at left apply to rocket; at right, to balloon. Four from top to bottom at left show azimuth angle, Doppler (radial velocity), range and elevation angle.

New Trends in Teaching

INNOVATIONS in education were described to the M.I.T. Alumni Council on February 29 by both Arthur R. von Hippel, Professor of Electrophysics, and Roy Lamson, Professor of Literature. William L. Taggart, Jr., '27, Vice-president of the Alumni Association, presided at this meeting and 179 members and guests attended.

Professor von Hippel spoke wittily of the need for interdepartmental centers, to encourage engineers to look behind the curtains of standards and handbooks, and prevent academic disciplines from becoming a Tower of Babel. He also dwelt on the importance of refresher courses, and called for both industrial and governmental support of fresh approaches to technological research and education.

Professor Lamson enthusiastically reported progress at the Institute in breaking down the barriers between professional and cultural education. He declared the standards of the new Course XXI match those of other courses and its graduates find themselves well equipped for advanced work in many different disciplines.

Finer Ball Bearings

A SIGNIFICANT technical advance in ball bearings has been made in the last five years at the initiative of the M.I.T. Instrumentation Laboratory. Ball bearings with tolerances of 20 millionths of an inch have been developed. This is 10 times better than standard requirements, and important in the nation's missile program.

A human hair is about 3,000 millionths of an inch thick. Bearings frequently are measured to tolerances from 10 to 20 times smaller, but the tolerances of these bearings is 150 times smaller than the thickness of a hair.

These ultra-precise bearings are used in the gyroscopes that go into inertial guidance systems. Gyros are the hearts of such systems. Their spinning is essential to keeping a vehicle on a particular course, and to obtain near perfect performance from the gyros the ball bearings that carry the spinning wheels must surpass the customary commercial standards.

"The development of super-accurate bearings is an example of the 'leap-frog' technique in the science and technology of inertial guidance," says William G. Denhard, '42, who is in charge of the Instrumentation Laboratory's inertial gyro group. "Ten years ago, in the relatively early days of work on inertial guidance, ball bearings that were used were more accurate in their geometry than other parts of the instruments that went into the guidance system. With the passage of time, there was a concerted effort to improve the machining and inspection of other parts, so that by 1955 these other parts had been improved to a degree that made them dimensionally superior to the bearings in terms of our needs."

Work with bearings now has improved them to a point that has resulted in a good balance in dimensional control. Today inertial guidance systems have better accuracy and reliability than was expected only a few years ago. While there will be more advances in bearing geometry, nothing approaching the recently achieved improvement is expected very soon; further improvements are likely to be in materials, design, and operational testing.

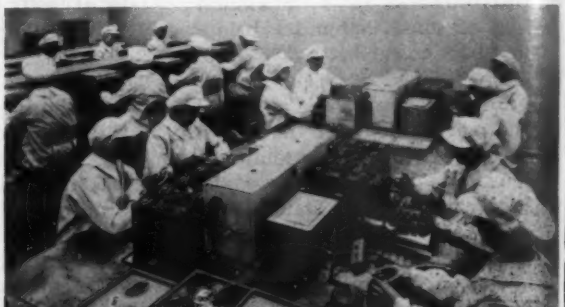
A team effort involving M.I.T., the Barden Corporation of Danbury, Conn., and the Ballistic Missile and the Wright Air Development Divisions of the Air Force's Air Research and Development Command in Dayton, Ohio, brought about the desired improvement in tolerances.

Tooling and measuring techniques that could assure such tolerances were limited as recently as the mid-1950's, and more adequate inspection methods had to be achieved before more precise ball bearings were produced. Air gauging devices, which measure dimensions by the amount of air escaping between a tube containing small bleeder holes and the piece being inspected, were in use; and linear transformer transducers, which indicate measurements by electronic methods, were coming into broader use. More adequate adaptations of these two types of gauging, and automatic gauging techniques, were needed.

In addition to developing measuring devices, the team developed model shop machine-tool techniques for increasing the percentage of highly accurate bearings; tooling methods and machine tools were modified in a long, painstaking process that required hand-crafting throughout. Now consistent dimensions have been attained, and inertial guidance is moving from an "industrial craftsman" production method to a "mass production" method while retaining the required standards of performance and control.

Although the need for such bearings has increased, the Barden Company still finds that such fine tolerances are needed in only a small fraction of 1 per cent of its total production.

Technician Ralph C. Brown of the M.I.T. Instrumentation Laboratory uses a balancer to eliminate dynamic unbalances in inertial guidance wheel and bearing assembly.



Women at the Barden Corporation's plant in Danbury, Conn., clean individual ball bearings in a super-clean area. Vibration testers are in foreground; spray booths in rear.

We're Older Than We Thought

FROM MIDNIGHT ON, night after night two years ago, Professor Fred Hoyle of Cambridge University toiled alone in the M.I.T. Computation Center. He was using its IBM 704 computer to trace the evolutionary development of stars. He has made more computations since then with other big machines, and these have led him to revise his opinion of the age of the galaxy which includes our little solar system. In 1955, from less complete calculations, he estimated our Milky Way's age at 6.2 billion years. Now he believes it is at least 10 billion years old.

Civil Engineering's Computer Laboratory

ESTABLISHMENT of a computer laboratory for M.I.T. civil engineering students, the first of its type in the nation, was announced this term by John B. Wilbur, '26, Head of the Department of Civil and Sanitary Engineering. Charles L. Miller, '51, Associate Professor of Surveying, will be its director and Robert A. Laflamme, '57, an instructor in civil engineering, will be responsible for technical supervision.

For this laboratory an IBM 650 has been installed in the basement of the main M.I.T. building. More than 1,500 IBM 650's are currently in use, and they have become known as the "workhorses" of data-processing machines. Fifty colleges and universities now are using the 650's for teaching and nonsponsored research under an IBM educational program.

Installation of the civil engineering computer brings to 10 the number of large data-processing devices now used on the M.I.T. campus. They include an IBM 704 high-speed computer at the Computation Center; another IBM 650 in the Instrumentation Laboratory; the TX-O, a noncommercial device built at Lincoln Laboratory and transferred to M.I.T. for both academic and research work at the Computation Center; a Bendix G-15 in the Naval Supersonic Laboratory; two Burroughs E-101's, one in the Aeroelasticity Laboratory of the Department of Aeronautics and Astronautics and the other at the Research Laboratory of Electronics; and three Royal-McBee LGP-30's, two in the Department of Meteorology and the other in the Research Laboratory of Electronics.

While most of the computers are for research purposes, the new machine in the Civil Engineering Department will be essentially for academic purposes, supplementing the heavy student programs already under way at the Computation Center. It will be operated as a general Institute facility on an "open shop" basis, with users furnishing their own operating personnel, or running the machine themselves. One-third of the computer time will be allocated to students taking courses in computer methods in the Civil Engineering Department, and one-third of the time will go to the School of Industrial Management. The remaining one-third will be available to other academic users throughout the Institute. Supporting equipment includes an accounting machine, sorter, reproducing punch, key punches, and verifier. The new laboratory also has placed an order with IBM for a solid-state computer to be delivered later.

"Electronic computers have become an important part of the practice of civil engineering during recent years," says Professor Miller. "The Department of Civil Engineering at M.I.T. has pioneered new solutions to engineering problems through computer methods. We have developed approaches which show the advantages of using small and medium computers at the problem sources as well as large-scale computers at central locations."

An outstanding example of a computer's value in civil engineering is the Digital Terrain System developed by Professor Miller, which has saved millions of dollars in planning and designing highways.

The High Cost of Journals

THE EMERGENCE of journals as the primary sources of new scientific information has posed a major problem to which W. N. Locke, Director of M.I.T. Libraries, called attention in his annual report.

"Although journals are far cheaper word for word than books, subscription rates have been going up," Professor Locke wrote. "Between 1948 and 1958, subscription rates have approximately doubled. They have gone up an average of 10 per cent in the last year alone. The story is the same for book prices. But the pinch is most severely felt in the fact that new journals must be added while subscriptions to most of the old ones are continued.

"During the year we submitted lists of the journals currently received to the Faculty Advisory Committees with the request that they eliminate every journal which is no longer needed. Some 25 out of a total of 3,053 journals currently received have been dropped. Another 20 ceased publication during the year. Only 67 new ones were added, but this is far short of the minimum needs. There is hardly a field in which important new journals did not appear during the year, most of which we were unable to buy for budgetary reasons.

"This compounded inflation of the rising cost of everything we buy and of salaries," Professor Locke concluded, "plus the need to keep up with an expanding world production of scientific literature, makes the libraries' bite on the general Institute budget all too reminiscent of the camel in the Arab's tent."

The Science Library at M.I.T. is used by more than 1,400 readers on some weekdays. Its shelves are nearly full and there is room left for less than three years' growth.

The Morale of M.I.T. Freshmen

A psychologist's report on the attitudes of the Class of 1961 reveals its high hopes and its first disappointments

BY JOHN I. MATTILL

Director of Publications

THE overriding impression of M.I.T. to the average member of the Class of 1961 as he finished his freshman work two years ago was this: M.I.T. is hard — harder than I thought it would be, so hard that I am missing a lot of the fun that I expected in my college years, so hard that I don't have time to pursue many of the ideas that come out of my courses.

But, although the class complained about the pace, most of its members agreed that the education they were getting was good, and they counted on its results to justify the hardships. By May some students approved of M.I.T. less than they had before coming, but the Institute gained in the eyes of about as many others.

Concerned about the attitudes and morale of M.I.T. students, the Undergraduate Association in 1957 commissioned Miss Leila Sussmann, Assistant Professor of Sociology at Wellesley College, to make a year-long study of the expectations and developing attitudes of the freshmen who would enter that fall.

The study began in July, 1957, when by a mail questionnaire Miss Sussmann and her group asked each member of the class about his hopes and expectations of M.I.T. and where he got them. After the class arrived some of its members were interviewed and four students kept daily diaries for the project. In the spring came reinterviews with the students first seen in the fall, and in May one-or-two-hour interviews with about 200 members of the class, picked at random.

Miss Sussmann's findings were published in a 100-page report this spring. Her conclusion: the morale of some M.I.T. freshmen is relatively low; they are mostly those

low in the class academically. But the problem "has no easy solution."

Killing Inquisitiveness?

The students who find M.I.T. most disappointing are by and large those who are ill-prepared, emotionally or academically, for its rigorous academic standards. These are the students who made outstanding records in high school without ever really learning how to study. They are the students who come to M.I.T. "with the strongest hopes for a typical 'collegiate' experience," much of which is denied them by the pressure of academic work, Miss Sussmann says.

Before coming to M.I.T. more than half the Class of 1961 expected to study 29 hours a week or less; but by May, 64 per cent of the class was putting in 30 or more hours, and 27 per cent 40 or more hours. The students whose performances at M.I.T. were best were generally those who had done more studying in high school. They had learned how to study, to get full measure from their homework time.

Some students complained that the pace was so demanding that they could barely keep up with their assigned work and never had time to explore on their own. One student, perhaps overstating the case, told Miss Sussmann: "One particular segment we're doing in physics is fascinating. . . . I'd like to spend the whole semester on it. But we're moving so fast you don't have time . . . I had a tremendously inquisitive type of mind, and they've succeeded in killing all the inquisitiveness."

The Norm of "Aiming High"

Before they came, the Class of 1961 expected a lot of M.I.T. Nearly all of them spoke of its high academic reputation, many referred to its excellent Faculty and facilities. By May many still agreed that their instructors "had a masterful command of their subjects." But many — especially those whose grades were far below what they hoped for — were critical of the teaching; they felt that many members of the Faculty were so interested in research that teaching took a secondary place.

M.I.T. draws its new classes each fall from the top of the country's high school graduates. This is a group of students accustomed to ranking near the top among their colleagues, and most of them expected to continue this performance at M.I.T. Before they arrived at the Institute, 96 per cent *hoped* to be at least that high in rank, accord-

By the spring of the year the freshmen were studying more hours per week than they had expected to study before they entered the Institute.

ing to Miss Sussmann. Obviously, almost half this group was doomed to disappointment. Even after mid-years, however, when students had seen their actual first-term grades, "there were still many more aiming for the top ranks in the class than there was room for. Actually, the distribution of rank aspirations changed little."

Most freshmen in every high-ranking American college have this kind of adjustment to make. But in one respect the behavior of M.I.T. students was "strikingly different" from that of college students who have been studied in psychology laboratory experiments elsewhere: there were no "under-aspirers" at M.I.T. – no students who set their future goals lower than their past performance. This difference, Miss Sussmann believes, is partly the result of studying a real instead of a laboratory situation. But she also believes that M.I.T. recruits a freshman population predisposed to high aspirations, perhaps higher than those in most other schools. And, Miss Sussmann says, "the norm of 'aiming high' is very strong among both students and Faculty here." It is not low grades in themselves, but low grades associated with aspirations for much higher ones, which produce low morale.

Living Groups as a Factor

Before they came to Cambridge, less than one-fifth of the Class of 1961 referred specifically to the Institute's dormitories and fraternities as something to which they were looking forward. But at the end of the first year, nearly half of the class rated their living groups as a positive factor in their experience.

This does not mean that everyone was happy about his life in a dormitory or fraternity. Miss Sussmann points out that most of these favorable comments were based on the students' enthusiasm for their personal freedom, the lack of rules and restrictions. Indeed, she concludes from her interviews that "living groups at M.I.T. are less satisfactory than they might be."

She found that students who chose single rooms, presumably to be sure of having uninterrupted study time, risked finding themselves "lost in anonymity" because they had no sure way of building friendships in the large group of dormitory residents. Those who chose suites found friends but paid a price in distraction from work.

Dormitory residents were dissatisfied with study conditions, and "they failed to find in dormitory life the college spirit which so many were looking for." Thus the dormitories, says Miss Sussmann, disappointed both "the students who wanted to work very hard *and* those who wanted to have a collegiate good time."

Students in fraternities were better satisfied with their living groups. They had no complaints about a lack of friendship or group spirit, though they complained with some frequency about poor study conditions. Miss Sussmann thinks their favorable answers may have been influenced by "a spirit of loyalty."

"The most notable increase" during the year in unfavorable comment about M.I.T., says Miss Sussmann, was "the large number of students who found the Institute impersonal and lacking in school spirit. The lack of satisfying, positive ties to other people was mentioned again and again. The majority of freshmen wanted and expected college to mean something in their lives beyond the acquisition of knowledge and skills.

The Problem of Values

What they probably meant, says Miss Sussmann, is that "they went through their first year as competitive individuals or as members of a very small group of friends." A unified college community never developed. Miss Sussmann believes that this condition – apparently not uncommon in engineering schools – results from the high demands of engineering and science curricula, which leave students little leisure; and from the fact that many engineering students (and this is true at M.I.T.), coming from working-class and lower-middle-class families, are likely to be more concerned with "achieving the requisites of high occupational status" after graduation than with "intellectual and emotional experimentation."

"The problem at M.I.T.," Miss Sussmann concludes, "is to create an undergraduate community centered on values which stem from intellectual and scientific pursuits." In times when the nation needs ever-higher standards of achievement in these fields, all eyes will be on M.I.T.'s solutions to a problem which arises out of the Institute's own unique achievements.

The Story Behind Polaris

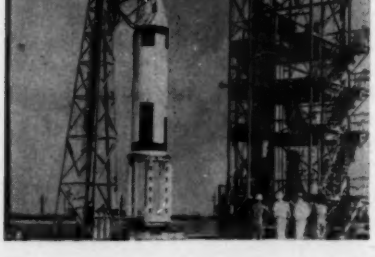
Many Alumni have worked on the new weapon system

THE MOST complex weapon system ever devised, in the opinion of experts, will become operational late this year when the nuclear submarine *George Washington* is armed with 16 Polaris missiles. Credit for two of the technological triumphs wedded in this system, the navigation of the submarine and the guidance of the missile, goes to the M.I.T. Instrumentation Laboratory.

"Only a few years ago," says Lt. Commander John B. Padgett, Jr., '54, "many technically qualified people said it was impossible to reduce the inertial guidance equipment then available to a size that would fit into a submarine-launched missile. But it has been done, and accuracy and reliability have been significantly improved at the same time."

Commander Padgett is a veteran of the submarine service and a 1945 graduate of the U.S. Naval Academy who is assigned full time to the Instrumentation Laboratory. He and another naval officer stationed there report to the Bureau of Ordnance Technical Liaison Officer at the General Electric plant in Pittsfield, Mass., where the inertial guidance systems are produced in accordance with design specifications furnished by M.I.T.

The first full-scale test of the inertial guidance system designed for the Polaris was made on January 7 and was successful; the missile flew 900 miles from Cape Canaveral. The system is similar to those designed for the Air Force's Titan and Thor missiles. Its size and weight are secret, but Commander Padgett considers the accomplishments since 1953 "phenomenal." That was the year in which Charles S. Draper, '26, Director of the Instrumentation Laboratory, made an historic transcontinental flight in a plane flown by an inertial guidance system that filled much of the cabin and weighed 2,800 pounds.



Inertial guidance represents a combination of several specialized fields of science and technology. Elements of mathematics, electronics, computer technology, mechanical design and circuit design had to be brought together to meet stringent requirements. To keep the Instrumentation Laboratory where this work was done close to M.I.T., it has been housed in an old, four-story, red brick building on Albany Street that formerly was a shoe-polish factory. The Polaris work was done mainly in a building that once was an industrial firm's garage. Three blocks west, down Albany Street, more employees of this laboratory work in what was once a wool-storage warehouse.

Key men on the M.I.T.-Polaris team under Dr. Draper have included many Alumni:

Forrest E. Houston, '48, Associate Director of the Laboratory, is a Naval Academy graduate who has been with M.I.T. since 1950 and has been a top administrative official on the Polaris project.

Ralph R. Ragan, '52, has directed technical development of the Polaris system, and occupies an office next door to the Navy's technical liaison officers.

David G. Hoag, '46, a systems

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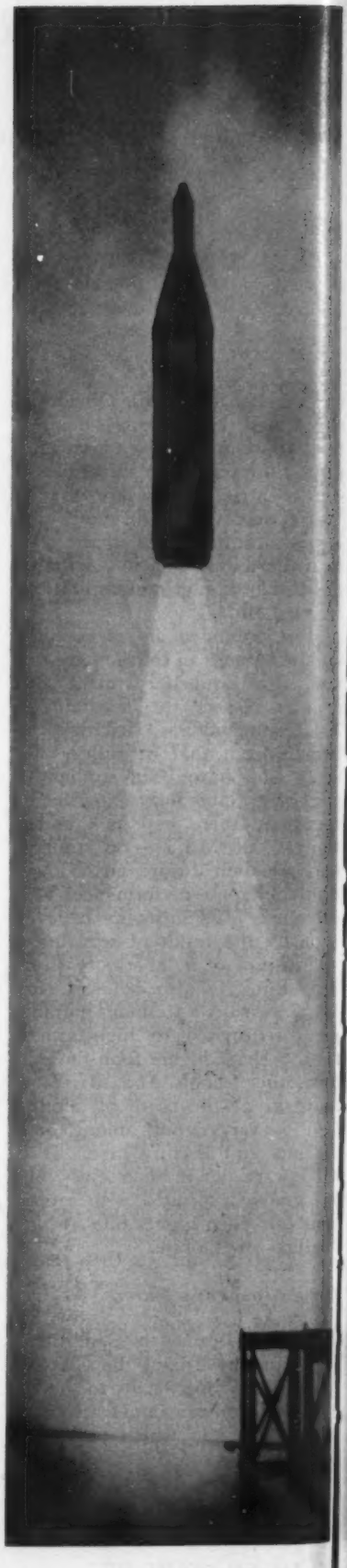


The Lady Is a Phony

The metallurgists' electron microbeam probe displays its versatility dramatically by verifying an artistic forgery

BEHIND a locked door on its third floor, the Boston Museum of Fine Arts has a collection of beautiful things that it never displays. Here, as well as downstairs, it has all types and all sizes of *objets d'art* from many parts of the world and many periods in mankind's history, but these are fraudulent.

They stand amid scientific instruments with which this has been proven. William J. Young, the greying gentleman who heads this laboratory, has devoted years — like his father and his grandfather — to exposing false labels. He and his colleagues in other museums and laboratories have examined many masterpieces fluoroscopically, spectroscopically, and with other modern aids to perception. But still some works of forgers hang in great museums and deceive collectors, dealers, and students of art — because of the craftiness, the talent, and the patience of the criminals who produced them.

Henceforth, fortunately, it will be easier to detect falsified art, thanks to the development of an instrument called an electron microbeam probe. Its potentiality in the art galleries was demonstrated this winter by an M.I.T. graduate student, Norman L. Peterson. With it, he proved beyond a possible shadow of doubt that a puzzling portrait of a lady which was purported to be the work of a Fifteenth Century Florentine artist was a phony.

The electron microbeam probe is so new that only a few researchers have used it. There are less than a dozen of these probes in this country and about the same number overseas. Already, however, they have revealed so much about a great variety of solid materials that the Institute will offer a special course next summer in the design and use of an electron probe.

This is part of the Boston Museum of Fine Arts' modern and well-equipped scientific laboratory. Miss Florence Whitmore is adjusting an optical spectrograph in the background; Miss Alice Zacharias is using a microphotometer in foreground. William J. Young is the laboratory's director.

To appreciate what Mr. Peterson did, you must know a bit about both the forger's bag of tricks and this new means of insight.

Buried Evidence

The prices now paid for ancient art are as alluring to some men as a bank's vault, and they have simulated it with incredible skill. They have pitted themselves against not only the experienced eyes of critics but also the x-rays, the microchemical techniques, and the historical and scientific records available to Mr. Young and his colleagues. The stakes for which they have played might make a Las Vegas croupier tremble. Hence the odds, to some gifted criminals, have not seemed too great.

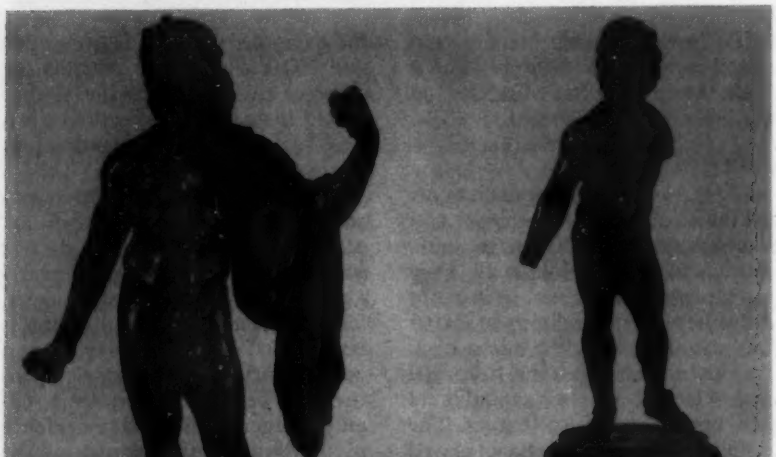
The forger never can wholly hide clues to his deceptiveness. Some of the materials and techniques of artists in bygone days and faraway places are no longer known — the secret of manufacturing a blue found in the Palace of Knossos in Crete and in Roman wall paintings, for example, was lost between 200 and 700 A.D. But it is possible for a forger to bury the material that would betray him so deeply in layers of paint or metal that suspicious men will not dig for it.

Honest investigators, their employers, and other lovers of art often are loathe to remove even a small part of a possibly irreplaceable object for chemical analysis. Their reluctance to mar what is represented as, and looks like, a genuine artistic and historic treasure can be counted on by a talented forger. Indisputable evidence of the guilt of the painter of the lady's portrait, which Mr. Peterson exposed, lay behind this barrier to the use of conventional techniques.

Mr. Young believed that this painting was a forgery. But it was on a wooden panel which seemed authentic, and the patina on the lady's portrait looked as though it had been placed there by age. Her profile had been painted over another picture which probably was inferior — but might not this have

A genuine example of Egyptian limestone sculpture and a forgery . . .

One of these is a Chou Dynasty ting; the other is a forgery . . .



One of these is a "Greek bronze statuette of Zeus"; the other is a forgery.

Can you recognize the forgeries? *In the top picture, the forgery is on the right; in the center picture it is on the left; at bottom, it is on the left.*

been done by a Florentine artist in the Fifteenth Century?

When part of the patina was removed, the portrait seemed strikingly beautiful. Many pictures comparable to it are highly valued. Mr. Young and others who saw the painting in his laboratory wished that it could be displayed publicly. Had the lady been wrongly imprisoned in his collection of fakes? Her admirers hoped so — and some of them thought so.

Materials Research

Mr. Young learned about the electron microbeam probe as a result of his friendship with Robert E. Ogilvie, '52, Assistant Professor of Metallurgy at M.I.T. It was being used in Professor Ogilvie's laboratory to study such matters as the cladding on the fuel elements in nuclear reactors and the history and composition of meteorites. Obviously, it also could penetrate mysteries that tantalize the curiosity of aesthetes as well as physicists.

Mr. Peterson used it, for example, to analyze some brown stripes, about which artists were curious, on a piece of Egyptian faience (decorated glazed quartz) that was produced about 2000 B.C. These stripes were only about half a millimeter wide, but tremendous compared to the amount needed for analysis. They were potassium silicate, Mr. Peterson reported, and contained a wee bit of iron which produced the color.

Similarly, he analyzed a speck of 4,000-year-old Egyptian glass, which was mainly blue but had a brown pattern on it, to explain this coloring. He found that cobalt was responsible for the blue and that the brown areas contained manganese.

He also demonstrated the probe's versatility by using it to examine a bit of glaze from a statue of a boy which was made in Whittington in the Eighteenth Century. After mounting this flake of material in bakelite, polishing it, and placing it in the instrument properly, Mr. Peterson reported that this glaze was mostly lead, but contained small amounts of zinc and iron.

The great advantage of the instrument was that not only a qualitative but also a quantitative analysis could be made of an extremely small piece of material. A mere sliver, thinner than a human hair,

would suffice. This was why the metallurgists were using the probe. They had found that with it they could trace the migration of one metal into another when two metals were bonded together and this, to them, was far more fascinating than the skulduggery of some artists.

This suggested to the metallurgists that they could employ the probe to explain the aging of metallic objects. With a sample of ancient bronze, Mr. Peterson found that the difference in the chemical activity of copper and tin had resulted in significant changes in the course of time. The tin had diffused outward, and had been leached away from the surface, where a copper oxide layer was formed over a tin oxide layer.

Professor Ogilvie pointed out while these experiments were being performed that the soldering in ancient objects also could be analyzed, and dated approximately by noting its diffusion into the material on which it had been placed. Work done to restore an ancient work of art might thus be disclosed. But might not a forger fool later investigators by holding his work at a high temperature before offering it for sale? No, because the diffusion gradient of, say, tin in copper, would differ in an item that had been annealed for a short time at a high temperature from that in one in which the diffusion had taken place at room temperature for a number of centuries.

Before a large picture such as the lady's portrait could be tested with an electron microbeam probe, however, a way had to be found to obtain a suitable sample of the material in it. Mr. Peterson revealed how this was done at the Chicago meeting of the American Association for the Advancement of Science.

How It Works

Some of the newspaper accounts of his work which were published then implied that an electron microbeam probe was a relatively simple little gadget. Actually, it is a large, complex, and very expensive instrument. In it, a finely focused beam of electrons is used to excite atoms. The radiation that these atoms then emit is analyzed to determine both what the atoms are and where they are. Such delicacy is not easily attained.

This is an electron microbeam probe. The electron gun is at the top of the upright tube. It sends a beam of electrons down toward the specimen, which is put in place with the help of an optical microscope.

One of the first electron probes in this country was made out of an electron microscope. It was designed by Victor G. Macres, '53, an assistant professor at Stanford University, and Professor Ogilvie. More have been built since at M.I.T. for the study of semiconductors, ceramics, precipitates in steel, and similar matters.

A French physicist, R. Castaing, developed the first electron microbeam probe in 1951, on the basis of the discoveries a few decades earlier of two famous Englishmen, W. H. Bragg and H. G. J. Moseley, regarding atomic phenomena.

Mr. Bragg found that, on the continuous x-ray spectrum that is emitted when a target is bombarded with high-speed electrons, a line-emission spectrum is superimposed, and that this line-emission spectrum has wavelengths that are characteristic of the elements in the material in the target. Mr. Moseley found a simple explanation of this: The higher the atomic number of the element that the electrons hit, the shorter the waves are, and the intensity of each characteristic wavelength is determined by the amount of the element in the target. The law which he formulated helped the chemists fill two of the blank spaces in their periodic table of the elements, and led later to the invention of the probe with which Mr. Peterson studied art.

Like a television tube, the probe contains an electron gun that shoots out a stream of electrons. As in an electron microscope, this beam is focused magnetically. Two magnetic lenses concentrate it on a very small area. To help you get whatever you want to analyze into this tiny area, an ordinary optical microscope is combined with the electron optical system.

The electron probe then does more for you than either a television tube or an electron microscope: Instead of merely giving you a picture of what's there, which might fool you, it tells you what is in whatever you are looking at. This is the part of the apparatus in which Mr. Moseley's discovery, regarding the x-rays emitted when high-energy electrons hit something, is put to work.

But how, you may wonder, is this done? How can the waves in

the radiation be sorted out and its parts measured separately? This is done by a mechanical maneuver as beautiful as a double play in baseball.

The x-rays that fly out of the target are intercepted by a crystal. It reflects them to a counter. This crystal is mounted on a hub of a wheel within a wheel. An electric motor turns these wheels while the x-rays are flying from the specimen to the crystal to the counter. Turning the wheels changes what the physicists call "the angle of diffraction," and the direction in which the crystal is facing determines which x-rays get to the counter. First, those with a short wavelength reach it. Then, as the crystal is turned, those having slightly longer waves get there, and so on and on.

By this scanning process, the parts of the radiation that are characteristic of different elements are distinguished, and the rest of the business is relatively simple. Circuitry of a quite customary sort is used to measure the intensity of the radiation reaching the counter while the crystal is turning, and a wiggly line is drawn on graph paper. The peaks on this line tell the operator what is in the specimen sending out the x-rays.

With the M.I.T. metallurgists' instrument, any element that is between magnesium and uranium in the periodic table can be found in an object that is only a micron (one-thousandth of a millimeter) in diameter.

The Evidence Obtained

The sophisticated example of art forgery which Mr. Young asked Mr. Peterson to investigate with this sophisticated device is about four times the size of a page of this magazine. How would you go about determining the authenticity of a painting that big with an instrument built to study things so tiny that you could put them in your eye and never feel them?

This was done the same way that a geologist finds out about parts of the earth which he cannot reach — but with a tool originally made for physicians to poke into their patients: A "core" of the material in the painting was extracted in a hypodermic needle. The finest needle on the market was used, and it was jabbed right into the lady's cheek.

You cannot see the hole that it left unless you stand very close to the picture and ask Mr. Young to point it out to you. Even so, the core that came out in the needle was 50 times as wide as really was needed. Finer needles can be made and the holes left — when pictures must be tested this way in the future — can be so small that they will be completely invisible to an art connoisseur's unaided eyes.

The next problem that confronted Mr. Peterson was how to expose the paint and other material inside the needle to the finely focused beam of electrons inside his instrument. This had to be done without contaminating or mixing the pigments. So Mr. Peterson filed away one side of the needle. Then he evaporated a thin layer of aluminum over this shred of evidence, in order to carry off the current of the electron beam, and thus prevent a charge from being built up that might deflect it.

A painting is a stratified structure, and when he placed this specimen in the probe, he could see distinct layers of paint with the help of the optical system. He was able, therefore, to focus the electron beam on these layers one at a time, and find out what was in each one.

The Analysis

The artist had covered the original painting with a layer of white. To give the lady her fine complexion, he also had mixed some green on his palette, and his brush had left a layer of it where the investigator's hypodermic needle pricked her cheek.

When the electrons were focused on the white layer, and the x-rays from it were scanned, Mr. Peterson saw that this white paint contained titanium. Similarly, when he focused the beam on the green part of the core, he saw that it contained chromium, and more titanium. It

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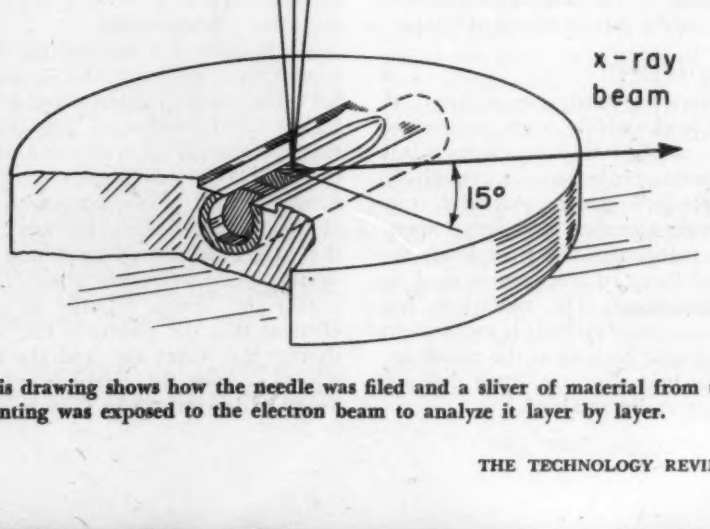
This is an enlarged photo of the "core" of material taken from the painting.



This drawing shows how the needle was filed and a sliver of material from the painting was exposed to the electron beam to analyze it layer by layer.

Factors in Scientific Strength

Innovation is influenced by a society's attitudes, its government's policies, and the quality and orientation of education

BY JAMES R. KILLIAN, JR.

(With sketches by Walter H. Lorraine)

On his recent world tour, the Chairman of the M.I.T. Corporation participated in an International Congress of Scientific Management at Sydney, Australia. The article which follows consists of excerpts from the paper Dr. Killian prepared for that conference.

THE USE of systematic scientific research for the creation of new knowledge and new technology, especially new industrial technology, is one of the most striking and most dynamically influential features of our time. Because this is widely recognized as true, because the economy, the health, and the vitality of nations are so profoundly affected by purposeful innovation, we witness today more perceptive attention to the factors which promote and sustain scientific strength.

At the risk of being pedantic, I wish to emphasize how innovation is inescapably influenced by the traditions and attitudes of societies, by the policies of governments, and by the quality and orientation of education.

Perhaps one of the most important constellations of attitudes and values which underlie scientific advance is the concept of progress which has been so central in Western civilization. This civilization has demonstrated a sustained eagerness to find better ways of doing things, together with the deep conviction that life does not have to be static, that movement toward improvement is possible. The revolution of modern man has been a revolt against things as they are when there are ways of doing things better. It has been a revolution against all of the forces which hinder man in seeking a better life. Science has had a major part to play in shaping this faith in creative change and improvement.

Scientific creativity, creativity of all kinds, is responsive to the values placed upon change and is deeply affected by willingness to recognize and support the gifted individual. These philosophical ideas of individual creativity and progress underlie scientific advance. The management of research is the art of providing optimum opportunity for creative people to produce change and progress.

Government's Contribution

Government policy and organization with respect to science is a second factor warranting emphasis in discussing a benign, ambient environment for research.

Governments of most great nations have large research programs of their own to manage; in addition, they sponsor research in nongovernment institutions and generate policies which either encourage or discourage research.

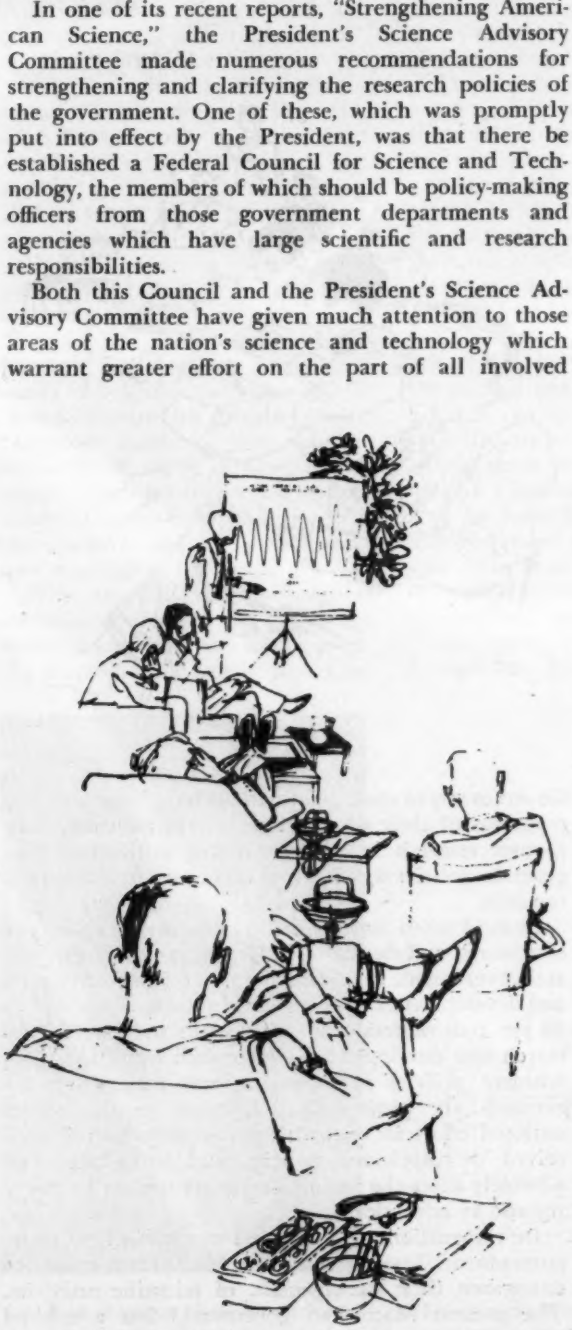
In the United States, a little more than 50 per cent of research and development is supported by the federal government. In 1956 federal government research and development contracts with industry amounted to 49 per cent of total expenditures in industry for research and development. Under such conditions government policies in managing and contracting for research are profoundly important to the whole national effort in research and development: ill-conceived or capricious policies and procedures can adversely affect the national science program in industry and in education.

In recognition of this great responsibility, many governments have recently made important moves to strengthen their management of scientific activities. The present Macmillan government has a cabinet officer, Viscount Hailsham, specifically responsible for

the government's science programs. In the United States, President Eisenhower, in 1957, appointed a Special Assistant to the President for Science and Technology. He also appointed the President's Science Advisory Committee, reporting directly to him. By these actions he sought to make available for himself and the other principal policy-making officers of government sound scientific advice, with the object of strengthening the government's own science programs and policies, identifying fields of science and technology requiring co-ordination and greater effort, and improving the government's policies and procedures for dealing with nongovernment institutions.

In one of its recent reports, "Strengthening American Science," the President's Science Advisory Committee made numerous recommendations for strengthening and clarifying the research policies of the government. One of these, which was promptly put into effect by the President, was that there be established a Federal Council for Science and Technology, the members of which should be policy-making officers from those government departments and agencies which have large scientific and research responsibilities.

Both this Council and the President's Science Advisory Committee have given much attention to those areas of the nation's science and technology which warrant greater effort on the part of all involved institutions, government and nongovernment. Materials science and engineering is a current example of a field where the federal government can encourage a greater concert of effort; it can provide such encouragement by stimulating more work in its own laboratories, in industrial research organizations, and in the universities, where the establishment of interdepartmental materials research centers can increase the output of scientists and engineers oriented toward materials research and development. If the government can help in encouraging national effort in such a field of opportunity, it can help industry as well as meet its own needs.



Australia provides an impressive demonstration of enlightened government sponsorship of research. The Commonwealth Scientific and Industrial Research Organization (CSIRO) has proved itself a great national resource, an instrumentality which has made notable contributions to basic and applied science and to the advancement of agriculture and industry. Other nations can profit much from observing the policies and procedures which have made it so effective – its freedom from political influence, its success in encouraging co-operative industrial research groups, its high level of scientific attainment, its important contributions to the advancement of such fundamental fields of science as radio astronomy.

One might appropriately note, too, that the new science of radio astronomy, to which the Radio Physics Division of CSIRO has contributed so importantly, had its scientific origins in a discovery made in an industrial research laboratory. CSIRO is a telling example of the importance of sound government policies and research management to a country's industrial and agricultural advance and to the enrichment of its science and technology.

Education's Contribution

The quality, level, and orientation of education is another factor upon which creativity greatly depends in any country. The existence of strong engineering schools of really professional caliber, whether a part of universities or separate from them, and the availability of first-rate graduate schools of both science and engineering are essential to nurture the professional engineers and scientists and to provide the centers of basic research which technically based industries require. The engineering profession has been retarded, and so has industry, in those environments where engineering education and technology itself have been only grudgingly accepted and developed within the university system.

It may be anticipated that marked changes in engineering education are impending and are, in fact, imperative. Engineering courses are tending to embrace more basic science and mathematics, to become more open-ended, and thus to educate engineers who are less narrow, more versatile in their engineering competence, and more broadly prepared for the nontechnical tasks of their profession. Engineers who have the capacity for synthesis, for systems management, must be educated in greater numbers.

A close relationship and understanding between education and industry, with each stimulating the other,

is important to the maintenance of a flourishing technology. Important, too, are the institutions below the level of the universities, the institutions which educate technicians, and the schools which provide the general education before students go on to universities or start their careers. Adequate science instruction in these secondary schools is of fundamental importance, not only in identifying and preparing talented young people for science and engineering, but also for achieving a widespread scientific literacy among all citizens.

These factors of attitude, tradition, public policy, and education are fundamental to the furtherance of innovation and to the maintenance of technological strength. They are the components of a nation's "system" of purposeful innovation, and the system does not function best without every component being carefully designed so that it fits and works together with the others. They need the understanding and attention of leaders in industry, government, and education if a country is to take full advantage of the scientific revolution which is now so profoundly affecting the life and economies of all nations.

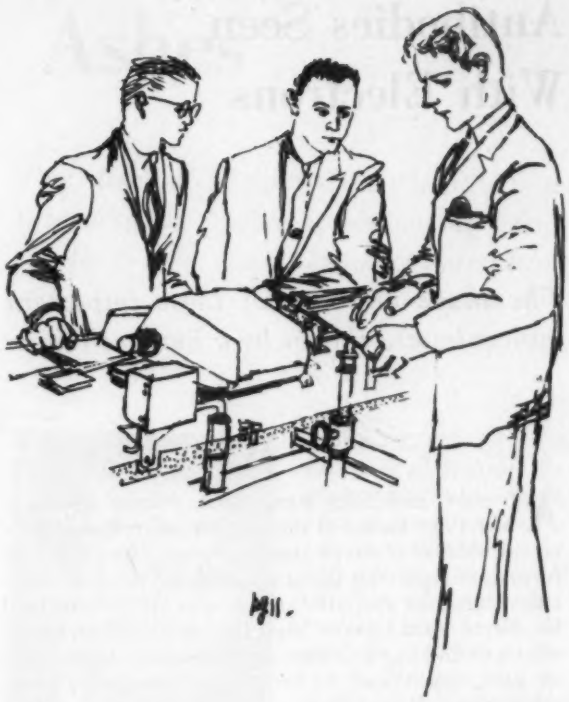
Management's Importance

In this connection it is appropriate to emphasize that the comparative scientific strength of countries can change; especially can a country lose ground rapidly or advance its position rapidly. In partial evidence let me summarize in the following table the distribution of Nobel Prizes in science since they were established.

NOBEL PRIZES IN SCIENCE
(Expressed in percentages)

Nation	*1901 1910*	*1911 1920*	*1921 1930*	*1931 1940*	*1941 1950*	*1951 1958*
United Kingdom	17	16	23	19	21	20
Germany	33	40	32	24	16	7
France	21	16	9	9	0	0
United States	4	6	9	24	37	47
U.S.S.R.	4	0	0	0	0	13
Other Nations	21	22	27	24	26	13

Clearly the art of research management must command more systematic attention on the part of industry, government, and other institutions engaged in purposeful innovation. The growing dependence of both nations and industries on successful research



together with the urgent necessity to use effectively the sharply limited supply of creative scientific talent in the world has put a high premium on mastering the art of research management.

Until now — when the Free World finds itself facing well-planned and able technological competition — research too frequently has been viewed as a kind of magic; or else management, not having penetrated its mystique, has viewed it with a romantic awe and taken it on faith. In other front offices, research has been looked upon as a mysterious black box which could be bought off the shelf and equipped with a button, which when pressed, yielded spectacular and profitable results. Such a concept of research is an open sesame to disaster.

In truth, research is not an occult art, but neither is it one that can be easily or casually mastered. It is a complex undertaking of human beings where success is dependent primarily upon high talent and secondarily on subtle factors of environment, of motivation, mission, and communication, of freedom and leadership. As a growing number of companies around the world have shown, there is, indeed, an achievable and transmittable administrative art for achieving sustained creativity, but as many other institutions have discovered, to their sorrow, this art of research management is one in which rigid or conventional concepts of management can be disastrously inadequate.

In an environment of "rising expectations," the cultivation of science and engineering in all their aspects is one of the principal means for advance and one of the principal hopes for man to realize a greater scope, a greater fulfillment of his human potential, a greater freedom, an augmented poise and dignity. Industrial science, in the hands of imaginative and creative management, holds this great promise and challenge today.

Antibodies Seen With Electrons

The shape and size of these important molecules are shown by a new technique

ANTIBODY molecules have been photographed at M.I.T. by means of the electron microscope and a recent method of preparing specimens. More exact information regarding the size and shape of these molecules than was available previously, can be obtained by direct visualization, and this may be helpful in efforts to find out how they are made. Such knowledge, in turn, could lead to further use of the antibody mechanism in medicine.

Studies over the last 40 years have shown that these "defenders" are generated in response to the presence of "invaders" called antigens. The antigens may include bacteria, their toxins, foreign red-blood corpuscles, tissue extracts, pollens, dust, and viruses. When the antigen enters the blood stream, the antibody is formed and combines with it, thereby removing the antigen. The production of antibodies is the basis of vaccination and the immunization process. Antibodies still are found circulating in the blood after antigens apparently have vanished, and humans remain immune to certain diseases long after the infection or the injection of a vaccine.

A Lock and Key Problem

A still puzzling feature of antibodies is that they cannot be told apart except by their reactions with antigens. In rabbits, whose antibodies have been studied most extensively, the antibodies and gamma globulin (the blood fraction that is believed to contain most antibodies) are indistinguishable. In antibody-antigen reactions, nevertheless, a "defender" is formed and combines with an "invader" in a relationship so specific that scientists compare it to a lock and key. The antibody created by the Salk vaccine, for example, will protect a person against only one antigen — polio. To see how, and why, efforts are being made to learn which part of the attacking antigen molecule is involved in the formation of its related antibody. One current belief is that the invading foreign molecule or a part of it may act as a template, and that the antibody's components string themselves together according to the arrangement of the atoms and molecules of the antigen. The electron microscope may contribute to the understanding of such phenomena by producing photos like the one on this page.

The recent work done with it at the Institute has been described in the *Journal of Biochemical and Biophysical Cytology* by Dr. Alfred Nisonoff of the Roswell Park Memorial Institute at Buffalo, N. Y., and Cecil E. Hall, '48, and Henry S. Slayter, '53, of M.I.T. Dr. Hall is an associate professor of biophysics and Mr. Slayter is a research assistant at the Institute.

Their photographs show large molecules of rabbit antibody and gamma globulin. This rabbit antibody was purified and prepared by a method developed by Dr. Nisonoff and Dr. David Pressman, the chief of biochemistry research at Roswell Park. An electron microscope technique developed by Professor Hall made it possible to measure the lengths and diameters of individual molecules of the antibody and gamma globulin by means of these pictures.

This involved spraying a solution of antibody on a mica surface, then evaporating particles of platinum in such a way that they piled up against the antibody molecules like snow drifting against a fence. The size and shape of the molecules were learned from the shadows cast by the platinum drift. This snow-fence effect and its shadows were photographed at a magnification of 15,000, and the measurements were made from prints of more than 100,000 magnification.

The Shape Is Cylindrical

The antibody and gamma globulin look alike in the photos, as expected, and consist mainly of asymmetrical rod-like particles about one-millionth of an inch long and from one-tenth to one-fifth as wide as they are long. The average dimensions found from the pictures agree with those deduced by other methods. But it was assumed that the molecules would have an egg shape, and the photos indicate that their shape is more nearly that of a cylindrical rod. This is an observation that may be useful in determining the steps in antibody formation.

Dr. Nisonoff has pointed out that the electron microscope may make it possible to locate the combining sites of antibodies, and the authors say that other work done with the electron microscope suggests the possibility of following antibodies as they build themselves up along foreign molecules, neutralize them, and remain on to confer immunity to infection.

Tomorrow's Hot Ashes

The disposal of radioactive wastes is an international problem; converting fission products into glasses reduces the volume

BY ROLF ELIASSEN

THE rapid growth of electrical power requirements, and the impending shortage of fossil fuels, virtually assure the nuclear power industry's future. The disposal of the radioactive wastes from this industry poses an international problem of such magnitude and complexity that research is imperative. The progress to date has been very satisfactory, but much remains to be done in several related scientific disciplines.

In the United States, electric power generation is expected to grow from the present installed capacity of 140 million kilowatts to 514 million kilowatts in 1980.[1] It also will grow, of course, elsewhere in the world.

By 1965 world-wide production of oil, which now amounts to four billion barrels per year, is expected to fall far behind the demand for it. Eugene Ayres has estimated that the United States production of oil will reach its peak in 1965; that natural gas production probably will begin to decline in 1970; that oil shales and tar sands will yield only a brief supply of oil; and that the bituminous coal supply of the United States will be greatly depleted by 1970, so that its rate of production will decline rapidly after that. "All the signs indicate we are within sight of the end of the fossil fuel era on our planet," he has written.[2]

Nuclear energy is the obvious source to which men will turn. By 1980, it is currently estimated, the United States will be generating from 100 to 175 million kilowatts of its electric power from nuclear fission. Reactors with this capacity would produce about 1,500 pounds of fission products per day.

Radioactive Wastes

Fission products have been likened to ashes; they will put out the fire unless removed. Power from fission involves a controlled chain reaction which will cease if all the neutrons are absorbed by other materials such as fission products.

It is common practice to use a fuel burn-up of about 120,000 kilowatt hours per pound of uranium before separating the fission products (the ashes) from the uranium and plutonium (the active fuel). Chemical means of separation are used. Strong acids such as hydrochloric, nitric, and hydrofluoric dissolve the cladding materials and the fuel elements. This is followed by organic solvent extraction of the fissionable material as plutonium metal solution and uranium oxide. Storage for a year of the waste that remains then permits the short-lived radioisotopes to decay.

ROLF ELIASSEN, '32, is Professor of Sanitary Engineering at M.I.T. He has been a consultant to the International Atomic Energy Agency, and attended an international conference in Monaco on the problem described in this article. He was also one of the contributors to the Handbook of Radiation Hygiene *(published by McGraw-Hill, 1959).*

Even after a year's decay, however, the radioactivity of the wastes now foreseen would be 100 billion curies per year. This is equivalent to the rate of disintegration of 100 billion grams of radium.

Compare this, please, with the tolerance value of mixed radioisotopes in water: The maximum permissible concentration is one ten-billionth of a curie per liter (principally because of the toxicity of strontium-90 and cesium-137). And the tolerance value in air is one ten-thousandth of the volume for water!

It would take all of the oceans of the earth to dilute one year's production of these wastes to the tolerance value. Discharging of these high-level wastes to the air or ocean, therefore, is not feasible. The users of atomic power will have to control the disposal of liquid wastes carefully to avoid contaminating the air, the ground, or the water resources of the world.

This applies to the users of mobile units as well as to operators of stationary reactors. Within the foreseeable future, about 200 naval vessels and 100 merchant vessels will be nuclear powered. The U.S. Navy has drawn up strict regulations to control the discharge of low-level fission product wastes in harbors and estuaries. Other countries, of course, are preparing similar regulations for their harbors and waterways.

The disposal of nuclear wastes in the open sea will be limited to low-level liquid and solid wastes. These have been placed in containers and sunk in 1,000 fath-

[1] Jackson, N. P., "Atomic Energy and the American Economy," *Journal of the American Water Works Association*, 47:1139 (1955).
[2] *Scientific American*, 195:43 (Oct., 1956).

oms of water. Low-level liquid wastes are discharged through pipelines in the coastal waters of the Irish Sea near England, but this is not likely to be done in the United States.

International conferences have been held under the sponsorship of the United Nations to draw up controls for the sea disposal of radioactive wastes. Eventually these controls will be assigned to the International Atomic Energy Agency with headquarters in Vienna.

The Tolerance Values

The object of these controls will be to assure that the tolerance value to human beings will not be exceeded. A critical tolerance value may be in the water that people consume or use for recreation, or in the fish harvested as food, or in the edible plants in which some radioactive substances may be concentrated after the plants have been irrigated.

How are tolerance values determined? The International Commission on Radiological Protection has established what are called "M.P.C." (maximum permissible concentration) values for the United Nations, and the National Committee on Radiation Protection and Measurements has established values for the United States. These, in turn, have been based on the decision that the maximum permissible dose to the entire population shall be five roentgens over a 30-year span. A roentgen is the unit of radiation energy causing tissue to absorb 93 ergs per gram.

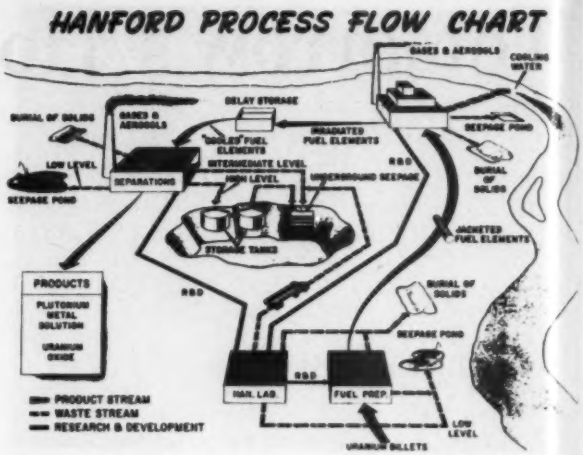
The reproductive organs (gonads) are the critical factor in determining tolerance values because they are the most sensitive part of the body to radiation. Professor George W. Beadle has estimated that this dosage will produce 0.33 mutations (children born different from normal) per 100 births.[3] He also has projected this selected mutation rate to include the probable number of new mutations in the United States and the world:

INDIVIDUALS BORN WITH NEW MUTATIONS

Cause	*Mutations per 100 births*	*In U.S. per year per 4,000,000 total births*	*In world per year per 80,000,000 total births*	*Generation per 2,400,000,000 total births*
Spontaneous	2	80,000	1,600,000	48,000,000
Fallout radiation	0.02	800	16,000	480,000
Medical radiation	0.2	8,000	160,000	4,800,000
Maximum permissible radiation dose to entire population	0.33	13,000	270,000	8,000,000

The last column presents a most formidable series of numbers and indicates the penalty we may have to pay for living with radioactivity. It gives rise to the philosophical question whether any council of men, be

[3] *Scientific American*, 201:219-231 (Sept., 1959).



This Hanford process flow chart was presented in the hearings on Industrial Radioactive Wastes Disposal of the Joint Committee on Atomic Energy of Congress [1:394 (1959)].

they national or international experts, has the right to predetermine the fate of so many newborn.

Allotment of Radioactivity

Cosmic radiation contributes an average of 0.1 roentgens per year, or three roentgens by the time a person is 30 years old (the mean age of childbearing). Medical radiation to the region of the gonads will be on the average three roentgens in 30 years. These exposures are not included in the five-roentgen M.P.C. value; they are either beyond man's control or necessary. Cosmic radiation may be a contributing factor in the spontaneous mutation rate shown in Professor Beadle's table. Fallout has averaged 0.01 roentgens per year; if continued on the same basis, it would use up 0.3 roentgen of the total allotment. That leaves a 30-year genetic dose of 4.7 roentgens to be allotted to future developments in peaceful uses of the atom.

One of the allotments is for the contribution which disposal of radioactive wastes will make to the environment. Last July the International Atomic Energy Agency tentatively allotted one twenty-fifth of the M.P.C., or 0.2 roentgens per 30 years, to disposal of wastes in the ocean. In the case of the discharge of low-level wastes from the Windscale installation into the Irish Sea, it was found that plaice (the bottom-feeding fish) was the critical factor in determining the allowable concentration of radioactivity in the outfall sewer and in the waters within a five-kilometer radius of influence.

Low-Level Wastes

When the radiation intensity from waste material is less than one millicurie per liter, the wastes are "low level." Such wastes may come from the mining and processing of radioactive ores, from research laboratories and hospitals using radioisotopes, from nuclear reactor cooling air or waters, or other sources.

Isotope users obtained 437,000 curies in 93,000 separate shipments during the years 1946 through 1958 from the Oak Ridge National Laboratory, the AEC's primary radioisotope supplier. The industrial uses of isotopes have multiplied and are estimated to have

saved major industries $40,000,000 a year. Most of these industrial uses do not yield any significant wastes.

Treatment for removal of radioactivity, or retention to allow for the decay of activity may be necessary, however, before low-level wastes are discharged to the environment. The Hanford reactor cooling waters, for example, are passed through retention basins before being discharged to the Columbia River, and radioactivity decays quickly in the basins and downstream. Other low-level wastes from the chemical processing plants at Hanford are discharged into the soil. The ground water is several hundred feet below the surface, so the sands have an opportunity to absorb the radioactive metallic ions by a cation exchange process, and thus far no activity has entered the Columbia River by percolation through the ground.

Discharge to the environment is also practical from other sources. The quantities discharged will vary, depending on available dilution and the proximity of the points of discharge to centers of population and other users of water, and a continuing program of radiation monitoring will be necessary to keep the radioactivity within the maximum permissible limits. Surveys of aquatic life in streams in this country that now are receiving radioactive wastes have not shown any dangerous reconcentration of radioactivity either from depositions on sands and river bottoms or from concentration by the algae and other plankton on which fish feed.

High-Level Wastes

The processing of nuclear fuel elements yields high-level wastes which must be stored for centuries before there is sufficient decay to permit release to the environment. The amount of these wastes now stored in underground tanks is estimated to be approaching 100 million gallons, and the contained radioactivity is measured in hundreds of millions of curies. These storage facilities are complex — precautions must be taken to control corrosion, temperature, and off-gases — and the cost is about two dollars per gallon of capacity. A better solution for permanent disposal must be found.

Volume reduction is a major problem. The AEC has sponsored waste disposal research at M.I.T. under my general direction for a number of years, and success has been achieved in the development of processes to reduce volumes by factors ranging from 5 to 20.

Wastes containing acid fission products and such cladding materials as aluminum, stainless steel, and zirconium have been converted to glass by the addition of silica sand, lime, and other fluxing agents and heating to 1400 degrees C. Water and acids are driven off, and a molten glass is formed and turned into a clear glass by sudden cooling. The cost of doing this can be less than two dollars per gallon.

Many tests have been made to develop glasses which will have a high retention of cesium and strontium, even in the presence of boiling water. Stable glasses can be stored in simple vaults or in abandoned salt mines.

Other means of reducing the volume of high-level wastes by sintering and fluidized solids processes also are the subject of experiments and pilot plant studies in this country. The feasibility of direct disposal of liquid wastes to salt mines is being investigated, too. There are vast abandoned caverns of this kind in many parts of the country.

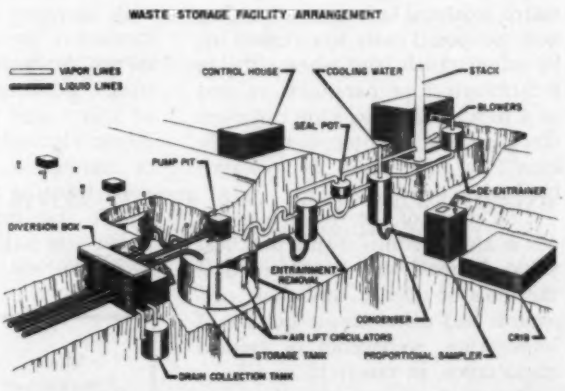
The International Problems

Russian engineers whom I met as a consultant to the International Atomic Energy Agency were interested in the results being obtained at M.I.T. and discussed similar results which they have been obtaining. Their expectation appeared to be that all radioactive wastes would be converted to glasses for controlled disposal.

At the recent International Conference on Radioactive Wastes Disposal in Monaco, the Japanese, Russian, Italian, and Canadian delegates were critical of the French, British, and United States policies. The Japanese complained of radioactive contamination of the Japan Sea from the Eniwetok weapons tests; and the Russians claimed that this had proceeded northward to the Kamchatkan Peninsula where they said fish were being contaminated. The Italians protested against the discharge of any radioactivity by the French into the streams leading into the Mediterranean because they feared contamination of their basic food supply. The Canadians raised objections to the discharge of wastes by the United States into the Columbia River because of claims that British Columbia's salmon industry was being affected. Neither the degree of contamination nor the possible effect on the public eating the fish was made clear by those protesting.

The International Atomic Energy Agency may become the arbiter in international disputes involving the discharge of radioactive wastes into coastal waters as well as to the open sea. The usefulness of this agency affiliated with the United Nations and the World Health Organization may be great.

Much research must be done by oceanographers, by sanitary engineers, and in other disciplines before definite answers can be given to many of the new international questions. Such work is being pursued actively by many research and development organizations, in several countries, and the progress being made is encouraging. I believe that advancing technology in the processing and disposal of airborne, liquid, and solid radioactive wastes certainly will keep abreast of, and probably forge ahead of, the prophesied rate of growth of mobile and stationary nuclear power plants and the attendant fuel-processing facilities.



A waste storage facility arrangement is complex and costly.

The Elements of Instruments

The logical grouping and coding of the parts of tools used in scientific research is helpful in several ways

BY KURT S. LION

KURT S. LION, Associate Professor of Applied Biophysics, received his doctorate at the Technical Institute in Darmstadt in 1932 and began his teaching career there. Later he held important posts at the Turkish State University in Istanbul and the University of Fribourg in Switzerland. Since 1941 he has been on the M.I.T. Faculty. This summer he will offer a course in biological and medical research.

TUCKED away on the shelves of our libraries, in countless books, periodicals, reports, or patents, is information about the methods that scientists are using or have used in their work. It describes the experimental systems they have employed, and the physical properties of these systems that are theoretically expected and experimentally realized.

Many of the excellent and ingenious methods and systems that have been devised bear the names of their inventors — Wheatstone's bridge, Rutherford-Geiger's counter, Michelson's interferometer, to name just a few examples. Numerous research workers have been awarded the Nobel prize for the development of new instruments or new methods; lately, for instance, Heyrovsky was honored for the development of the polarographic analysis method and Cerenkov for a nuclear counter.

Elements of Instruments

The study of these methods can be fascinating and rewarding. There are crude and refined methods, some that make us smile and others that we call "elegant." Some ideas are formed and are carried to perfection by generations of research workers. Other methods that were proposed early were taken up by others much later when either a technological preparedness existed or a new need arose. One can even recognize the existence of "fashions" in the field of research methods.

The study of the research methods is also of considerable practical value. Methods can be regarded as the tools of science, and their possession and discriminate use are of importance, sometimes of critical importance, in research.

One of the reasons for the enormous advances of the physical sciences is the natural coherence and logic with which the single observed phenomena fit together and form a unified field. The field of research methods also shows a clear pattern. The single research methods described in the literature can be grouped to form a unit that has all the characteristics of a science, the Science of Instrumentation. And a logical organization is important, not only because it permits an adequate coverage of the entire field without omissions or duplications, but also because it makes teaching of physical research methods that much easier.

Walk along the halls of M.I.T. and look into the different research laboratories. You will see thousands of instruments and it will seem impossible ever to master all these instruments and methods. Now it is not necessary to become familiar with all these instruments. All instruments are composed of "elements," or units or blocks, each of which performs a particular task or solves one particular problem. These elements recur in one form or another in all instruments.

By learning the "elements" from which the instruments are composed you will have at your command not only all the instruments that exist but a great many more. Learning the "elements" is comparatively easy, because their number is limited.

Three Basic Types

In the field of electrical instruments there are only three basic types:

1) *Input Transducers* or sensing elements. These convert any physical quantity into an electrical signal (for example, a microphone, a strain gauge, a photoelectric cell).

2) *Modifiers.* These convert an electric signal into another, modified, electric signal (for example, an amplifier, a filter, an integrator).

3) *Output Transducers.* These convert an electric signal into a physical quantity that is not an electric signal (for example, a meter, a strobotron, a light valve).

By combining appropriate elements into a system, in accordance with the well-known rules and laws that govern the behavior of complex systems, the research worker has at his command a tool of almost unbelievable flexibility. What is more, the logical grouping shows clearly where the status of the art

(Continued on page 46)

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Samples were made up, using a Revere Brass Strip with a smaller grain size than the manufacturer had been using. Tests showed that, as a result of the change the manufacturer was able to realize a saving of 17¢ per mirror frame on polishing costs alone, with no increased costs in other operations, including the 90° bend. Based on the saving per frame this manufacturer has saved $10,000 per year for the past 4 years!

So the next time you look into the mirror of your medicine chest while shaving, reflect on the saving made possible by properly "fitting the metal to the job." And remember that Revere's Technical Advisory Service may be able to help you realize savings similar to that of the mirror frame manufacturer.

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Institute Yesteryears

25 Years Ago . . .

ANNOUNCEMENT was made in The Review for April, 1935, of the development by Athelstan F. Spilhaus, '33, a research assistant in the Division of Meteorology, of "an instrument which analyzes temperature and relative humidity and, in a single reading, indicates prevailing weather conditions in terms of personal comfort. . .

"The device, which is known as an air-mass indicator, combines a bimetal thermometer and a hair-hygrometer, which react to temperature and humidity to register atmospheric conditions in a single reading. The instrument is expected to be especially valuable in warning pilots of the dangerous conditions of temperature and humidity in which ice begins to form on airplane wings. . ."

Also, it "promises to be useful in indicating zones of comfort to be maintained in air-conditioned buildings. Comfort at comparatively low temperatures requires higher humidities than the corresponding degree of comfort at high temperatures. Thus with a high temperature the humidity should be low, while with a low temperature a high humidity is desirable. The reason for this is that at low humidities evaporation from the body is more rapid and the process produces a cooling effect. At low temperatures such a cooling effect is uncomfortable, and can be prevented by a higher humidity. . ."

¶Kudos in the form of medals came to four Alumni, namely: to Henry E. Warren, '94, the Lamme of the American Institute of Electrical Engineers "for contributions to the development of electric clocks and means of controlling central station frequencies". . . to Frank B. Jewett, '03, the Faraday of the British Institution of Electrical Engineers . . . to Charles A. Kraus, '08, the Willard Gibbs of the American Chemical Society . . . and to Harold L. Hazen, '24, the Levy of the Franklin Institute.

50 Years Ago . . .

ON APRIL 28, 1910, at the 5th meeting of the Alumni Council, President Richard C. Maclaurin of the Institute, assured members of the Council that its reports and suggestions as to Institute policy were most welcome by the Executive Committee of the Corporation.

As reported by The Review, Dr. Maclaurin "acknowledged that the site problem is one of the greatest before the Executive Committee, and the Committee is working earnestly toward a solution. He believed the members of the Council would agree that it would be unwise and very unbusinesslike to make public the exact plans of the Executive Committee or to suggest what sites, if any, are being definitely

(Concluded on page 40)

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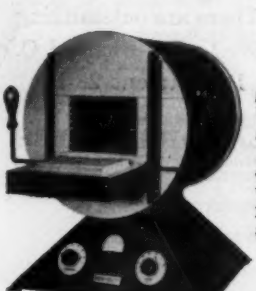

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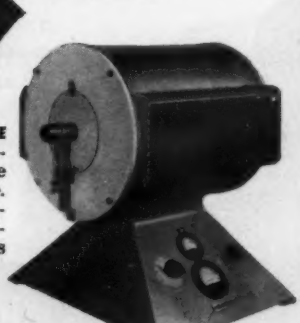

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Elton E. Staples, '26, *Vice President*
Chester Meyer, '36, *Assistant Secretary*

Institute Yesteryears

(*Concluded from page 38*)

considered. He also asked the Council to realize how foolish it would be for the Institute to sell its present property [in Boston] at a figure which would be a tremendous sacrifice as compared with a possible income which could be received from the sale of the land in a few years, when the rights of the abutters would grow less or could be bought at a more reasonable figure."

75 Years Ago . . .

ON SATURDAY, April 11, 1885, the Freshman battalion gave an exhibition drill at the Soldiers' Home Carnival which, said *The Tech*, "seemed to be highly appreciated by the visitors. The young ladies attending the booths were especially struck by their appearance, and gave special rates to students.

"The elegant stand of colors, to be given to the most popular military organization in the state, was won by the Techs. The vote stood: Techs, 1,358; Post 5, G.A.R., 1,042. These flags will be carried in the future by all M.I.T. battalions."

¶As indicative of the lack of gracious living suffered in and about Copley Square by students, the editor invited attention to the problem of lunching.

"Last year," he wrote, "a vague rumor was in circulation that a restaurant was to be established in the immediate vicinity of our buildings; it was soon disproved, however, and, as before, the weary Tech man trudged down town for his noonday meal. Nor is there any possibility of a good eating-house in this neighborhood; for, while the students of the Institute and adjacent schools would furnish a thriving business eight months of the year, very little support could be derived in the four months of summer from this neighborhood. . .

"A few years ago . . . the Catalogue used to announce that good board could be obtained at the Institute restaurant. The Faculty has apparently lost all interest in our convenience, since this statement is no longer made . . . It would seem as though the Faculty might offer a little assistance in this matter."*

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*The relationship between living conditions and student morale nowadays is considered in the article on page 22 this month.

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Books

EDMUND BURKE AND IRELAND, by Thomas H. D. Mahoney, Associate Professor of History at M.I.T.; Harvard University Press, $7.50. *Reviewed by Charles M. Gray, Assistant Professor of History.*

EDMUND BURKE is well remembered for championing conciliation with America and justice in India. He is perhaps best remembered for striking at the roots of the Revolution in France. His place in the history of conservative thought is as secure as his eminence among English orators. To Professor Mahoney's book we owe full awareness of a theme in Burke's career which has been much less well known. If Burke's concern for the amelioration of conditions in his native Ireland lacks the éclat of other themes, still it is the most persistently recurrent one. Without it the symphony would be different and less good.

The malady of Eighteenth Century Ireland was complex. Diagnoses and prescriptions could vary. To Burke, the center of infection was formed by the many legal disabilities attached to Roman Catholics. English Catholics lived under the same inheritance of pointless indignity, an inheritance to which contemporary bigotry still lent a sinister life. But in England the Catholics were a minority; in Ireland they were a nation. As a nation, they found no expression. Ireland was self-governing, though in a second-class way, for the sovereignty of her parliament was subject to supereminent powers of the British government. But in so far as she was self-governing, rule belonged to the small Protestant minority, essentially to the Anglo-Irish Landlords whose political ascendancy went hand in hand with economic exploitation. Burke's efforts were predominantly engaged in working for the emancipation of the Catholics and their incorporation into the country's political life. These efforts were not wholly fruitless, but Burke was rightly, disappointed at how far short of the requirements of justice and prudence the achievement fell.

Professor Mahoney has made it equally clear what Burke's approach to Ireland was not. In 1782, under pressures raised by the American war, Ireland achieved legislative independence. Burke's attitude toward this step was acquiescence rather than enthusiasm. Commercial discrimination was among Ireland's grievances, and early in his career Burke worked for improvement in this area, but he opposed a much more extensive liberation of Irish trade proposed by Pitt in 1785. Radical approaches – full Irish independence, union with Great Britain on the Scottish model, revolutionary methods, and Parliamentary reform – met no favor from Burke. To some, his championship of Ireland may seem so overlaid with caution and reservations as to lack any heroic quality. Despite his frank admiration for Burke, Professor Mahoney does not indulge

(Continued on page 44)

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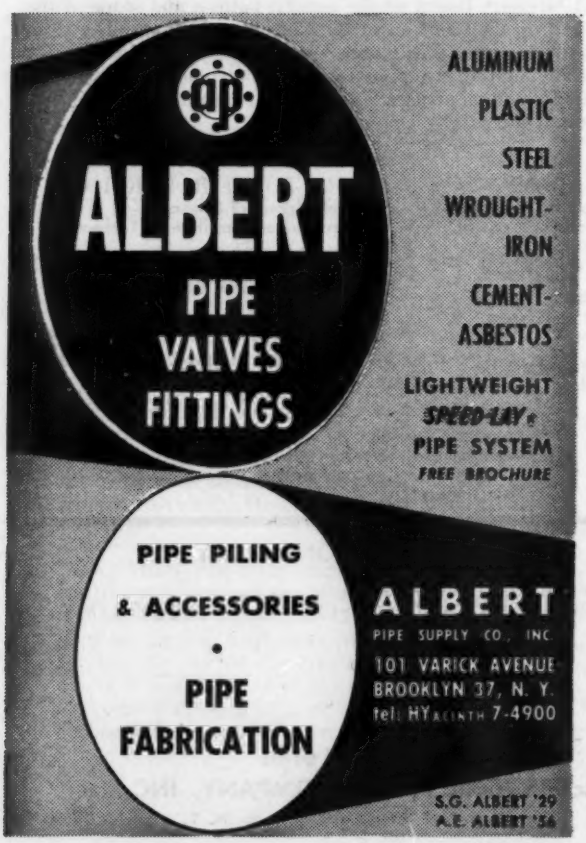

Books

(*Continued from page 42*)

his record on free trade and reform. It remains important to understand that Burke harmonized his feelings about Ireland into a delicately wrought pattern of political thought and vision. He saw the prospect of an "imperial" Britain in which Ireland would be included, in which the members would thrive without losing their subordination to the head, and in which the historic integrity of English institutions would not be violated. The complexity of his vision qualified what he could do for Ireland, but he never lost sight of what was most crucial.

Professor Mahoney has pursued his research with tireless care and presented his material clearly and judiciously. Because the book is extensively based on manuscript material only recently made available, it has a significance for the general study of Burke beyond the limits of the special subject.

ATOMIC ENERGY IN THE SOVIET UNION, by Arnold Kramish; Stanford University Press, $4.50. *Reviewed by Manson Benedict, '32, Professor of Nuclear Engineering.*

MR. KRAMISH's valuable book traces the development in Russia of nuclear physics and its practical applications from the early work of Kapitsa in the 1920's to the most recent Russian accomplishments in nuclear power stations and nuclear propulsion. The impressive number and variety of sources drawn on by the author include Russian newspapers and technical journals, information presented by Russian scientists and engineers at international conferences, disclosures by *émigrés* from Russia, and accounts of visitors to Russia as recent as those of Mr. Nixon and Admiral Rickover. Developments in Russia in such fields as atomic weapons, atomic power, particle accelerators and radioisotopes are contrasted and compared with developments in the United States.

A few examples will illustrate the interesting comparisons made by Mr. Kramish between atomic developments in Russia and in other countries. Although the principal discoveries in nuclear physics before the war are usually considered to have occurred in Germany, France, England, and the United States, Russian scientists also made important contributions, including the discovery of spontaneous fission. The war stopped all work in applied nuclear physics in Russia, whereas it accelerated it in the United States through creation of the Manhattan District. After Hiroshima, when the decision was made to produce atomic weapons in Russia, the development there proceeded as rapidly as it had in the United States. Recently, the Russians have been conducting experiments, with thousands of tons of conventional explosives in China; this may either presage large-scale peaceful utilization of atomic explosives to alter river beds or extract minerals, as proposed in the U.S. Project Plowshare, or it may be intended to screen clandestine tests of atomic weapons in the "vast geographical and political void of Red China."

(*Concluded on page 54*)

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The Elements of Instruments

(*Continued from page 36*)

is lacking, and where new invention is needed. All that is required is a handbook giving qualitative and quantitative information regarding existing elements.*

A Code for Instruments

Yet, there is more to it. The proposed organization permits the representation of any instrument in terms of the elements from which it is composed. If the elements are coded, the entire instrument can be expressed in a logical code system. For instance, the simple system illustrated on page 36 may be a vibration meter; the input transducer has a mechanical input (Group I_1) and is sensitive to displacements (I_{1C}). The modifier is an amplifier (M_{2B}), and the output transducer is a meter (O_{2A}) or a recorder (O_{3A}). Therefore, the entire system is described, in its generic form, by the code

$$I_{1C} \rightarrow M_{2B} \rightarrow O_{2A}.$$

Any system that has the same input and output but contains an unspecified modifier would be represented by

$$I_{1C} \rightarrow M \rightarrow O_{2A}.$$

* The organization and compilation of such a handbook is one of the goals of our group at M.I.T. Vol. 1 of this handbook has been published (McGraw-Hill Book Co., Inc., New York, N.Y., 1959). The project is supported by the Office of Naval Research.

A Freshman and a Friend Make Radio News

AN M.I.T. FRESHMAN, Raphael Soifer, and a friend possibly were the first radio hams to use an artificial satellite, when they exchanged coded signals February 6 between New York City and Bethesda, Md. Two satellites were nearby, and Soifer believes the signals were reradiated by a satellite's antenna or bounced off an ionized trail behind it. He plans more tests this spring.

The establishment of such a logical code system is of importance in all those cases where computer techniques are used. The greatest need for such techniques at present is in literature searching and information retrieval. Much has been written about the ever-increasing flood of scientific publications and the need for machine-handled searching. The situation is particularly serious in the study of instrumentation because contributions to the field come from sources as diversified as pure physics and aeronautical engineering, anesthesiology and steel production, enemy attack warning systems and respiration measurements in clinical medicine. There is some hope that the greater part of the literature search problem (or "information matching" problem, as it has been aptly called) in the field of instrumentation can be solved with the help of the code system mentioned above and a suitable abstract service.

A Rose by Another Name

Admittedly, the name "instrumentation" is not a product of Madison Avenue. It is misleading and it emphasizes a technical embodiment which is temporary, rather than the method which is permanent. The word "methodology" (coined, originally, by the philosopher Immanuel Kant) seems to be much more descriptive of the content of the described field. Other names have been proposed, too, such as instrumentology, metrology, and metronomy. Courses in this field that are given at German and Swiss uni-

(*Concluded on page 48*)

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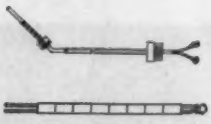

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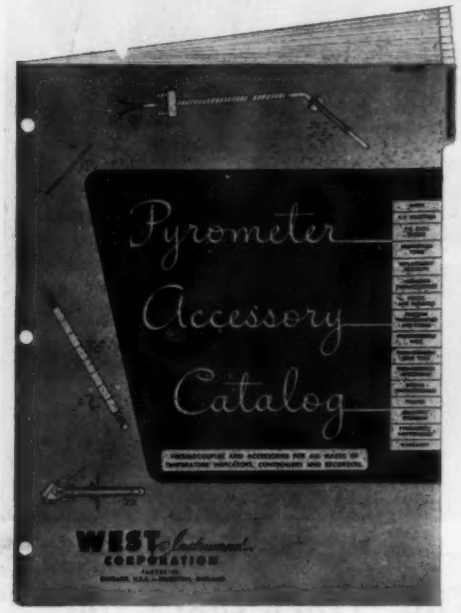

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The Elements of Instruments

(*Concluded from page 46*)

versities bear the title *Physikalische Messkunde*, a name which defies translation.

There are other considerations. There already is quite a literature under the name of instrumentation. There is a *Review of Scientific Instruments* and a *Journal of Scientific Instruments*, and in the light of the accepted nomenclature it seems rather futile to advocate a new name for a field of science, even if it would be more descriptive of the content.

An Educational Opportunity

Teaching instrumentation can be a considerable challenge. The field has all the characteristics required of a science: it is simple in its structure, logical, and aesthetically acceptable. Presented in a proper way, it stimulates creativity as an academic subject should. The wide spread of instrumentation furnishes examples of great variety, from fields as different as musicology (harmonic analysis methods) and astronomy (noise suppression in photomultipliers).

Education in Instrumentation is primarily of value because it gives one a deeper insight into physical processes and because the concept of instrumentation elements is a great aid in thinking, even in fields outside of the scope of physics. In fact, the language of modern biology, anthropology, and social science has adopted many idioms which originally were reserved for instrumentation elements.

Finally, we should not apologize for the fact that knowledge of instrumentation is of considerable practical value to nearly every scientist and engineer. Many of the modern demands of the pure physical sciences, the engineering sciences, biology, medicine, psychology, and others, be they on the academic or industrial level, require more than chance familiarity with the field of instrumentation. It is not surprising, therefore, that many institutions and departments offer formal courses in instrumentation, and it is to be expected that a general Instrumentation course on a broad basis will emerge in the near future.

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Story Behind Polaris

(*Concluded from page 24*)

engineer, has generated unique guidance techniques which have simplified and improved the overall system.

J. H. Laning, Jr., '40, a mathematician, has been responsible for concepts incorporated in the Polaris and in other missiles and air vehicles.

Wallace E. Vander Velde, '56, an expert on high-performance autopilots for military aircraft, also has contributed to Polaris guidance concepts.

Edward J. Hall, '57, works on design of components of almost incredible sensitivity.

John B. Nugent, '37, has been responsible for design work on the Polaris and other missile systems.

Eldon C. Hall, '53, was the group leader responsible for the development of the Polaris logic and circuit design.

The Instrumentation Laboratory's educational director, Walter Wrigley, '34, Professor of Instrumentation and Astronautics, has worked with Dr. Draper since the early days and now has responsibility for devising curricula for M.I.T. classes which qualified Naval officers attend. The classes are open, too, to officers of other services and some civilians, but all students must have a security clearance for certain postgraduate courses. Unclassified courses are offered for M.I.T. undergraduates.

"The Navy is placing increasing emphasis on postgraduate education in scientific subjects," says Commander Padgett, "and the inertial guidance courses offered at M.I.T. are among the most important of all. Many officers now in the Special Projects program, especially those who will be directly concerned with either surface ship or submarine guidance, received their training at the Institute. The courses are rigorous and demand complete concentration."

Prime contractors for the Polaris, in addition to M.I.T., include the Lockheed Aircraft Corporation, Aerojet-General Corporation, and General Electric, and there are reported to be more than 3,000 sub-contractors.

Individuals Noteworthy

(*Concluded from page 12*)

Names in the News

PROFESSORS *Jerrold R. Zacharias, Francis Bitter,* and *Francis L. Friedman, '49,* of M.I.T. are members of the steering committee for an effort to improve college physics courses sponsored by the American Association of Physics Teachers . . . *E. Francis Bowditch,* Dean of Students at M.I.T. from 1951 to 1956, will be Chief Marshal at Harvard University's commencement on June 16 . . . *James R. Aronson, '58,* and *John S. Waugh,* Associate Professor of Chemistry at M.I.T., are on the Russian translation staff of *Optics and Spectroscopy,* a publication of the Optical Society of America . . . *William E. Rogers, Jr., '50,* is one of the directors of a study of the possible effect of fluoride on retention of radioactive strontium in bones, at Indiana University . . . *Marshall Crouch,* former staff member of the M.I.T. Radiation Laboratory, will be the State Department's Deputy Science Officer for Tokyo.

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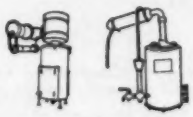

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A basic mathematical and experimental analysis of fluid-power devices, with abundant design information on hydraulic and pneumatic systems and components. Based on the work of the fluid-power group of the M.I.T. Dynamic Analysis and Control Laboratory. 710 p., illus. $17.50

The Internal Combustion Engine in Theory and Practice
By C. Fayette Taylor
The first volume of a two-volume definitive work on the internal combustion engine. Full design and performance data in many charts, curves, and tables. Illustrative examples. 574 p., illus. $16.00

Hydromagnetic Channel Flows
By Lawson P. Harris
Analyses of three kinds of flow of viscous, incompressible, electrically conducting fluids in high-aspect-ratio rectangular channels subjected to transverse magnetic fields; turbulent flow in the presence of a d-c magnetic field, and both laminar and turbulent induction-driven flows. 90 p., illus. $2.75

Experiencing Architecture
By Steen Eiler Rasmussen
A richly illustrated introduction to architecture that moves easily from tennis balls to cathedrals, from Copenhagen sidewalks to modern American buildings. 251 p., illus. $4.50

Word and Object
By Willard Van Orman Quine
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The Lady Is a Phony

(Concluded from page 28)

wasn't really necessary to look into the core of matter any farther.

Titanium was first used in paint in 1916, and has only been found in the pigments of portraits made since 1920. Chromium has been used longer, and chromium oxide might be found in a painting made as long ago as 1862. These and other such dates are matters of record, verifiable in numerous ways. Neither titanium nor chromium would have been in this masterpiece if it had been the work of a Fifteenth Century Florentine artist. It was clearly a forgery, and a recent one.

Suppose, however, that the forger had not covered the original picture below the lady's portrait in this way. He might, instead, have tried to enhance the value of a Fifteenth Century picture simply by putting a famous artist's signature on it. This is an old and less exacting kind of deception. But in this case the needle could have been inserted into the signature. Then the pigments of the paint used for the signature could have been compared, in the electron microbeam probe, with those in the painting beneath it.

Nature's masquerades often are more effective than those devised by men's cupidity, and some of these are being explained with this instrument at M.I.T. Its uses in determining the homogeneity of glass, ceramics, and other combinations of elements – and similar mysteries regarding materials to which men entrust their very lives – will be emphasized in the course which Professor John T. Norton, Professor Ogilvie, and others will give this summer.

There may be but few students of art and history in their classroom. Nevertheless, Mr. Young welcomes this move to show the probe's achievements, limitations, and potentialities to more scientists. Few museums are as well manned and equipped as Boston's to scrutinize art scientifically, and its laboratory is fully three years behind in its work. When more schools and industrial laboratories can lend a hand the way that M.I.T. has to the world of art, Mr. Young feels certain, there will be fewer phony Fifteenth Century ladies adrift.

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Books

(Concluded from page 44)

Mr. Kramish has brought an unusually appropriate combination of talents to the preparation of his book. His education as a physicist, his facility with the Russian language, his familiarity with the U.S. atomic energy program, and his experience as an intelligence analyst add authority to every page.

Atomic Energy in the Soviet Union is interesting to the general reader, essential to the student of Russian affairs, and valuable as a reference source. It is well documented and has a comprehensive bibliography and a complete index. The book is extremely detailed and accurate. No relevant public information known to the reviewer is missing.

And yet, there are many tantalizing gaps in this account of Russian nuclear developments. The record of the Russian atomic weapons program is sketchy, with next to nothing told about the location of Russian weapon centers, the production methods employed, the men responsible for the development, or its costs. This lack, of course, testifies to the effectiveness of the Russian security system and the absence of a Russian Smyth report. Similarly, there is little information given on Russian uranium deposits, their nature, location, reserve tonnages, or production rates. This, too, is attributable to the Russian policy of holding such information secret.

The reader will conclude from this book that Russia has been a formidable competitor of the United States in pure nuclear science and in its industrial and military applications. The large number of nuclear research centers recently established in Russia provide no complacency for us about the outcome of future competition.

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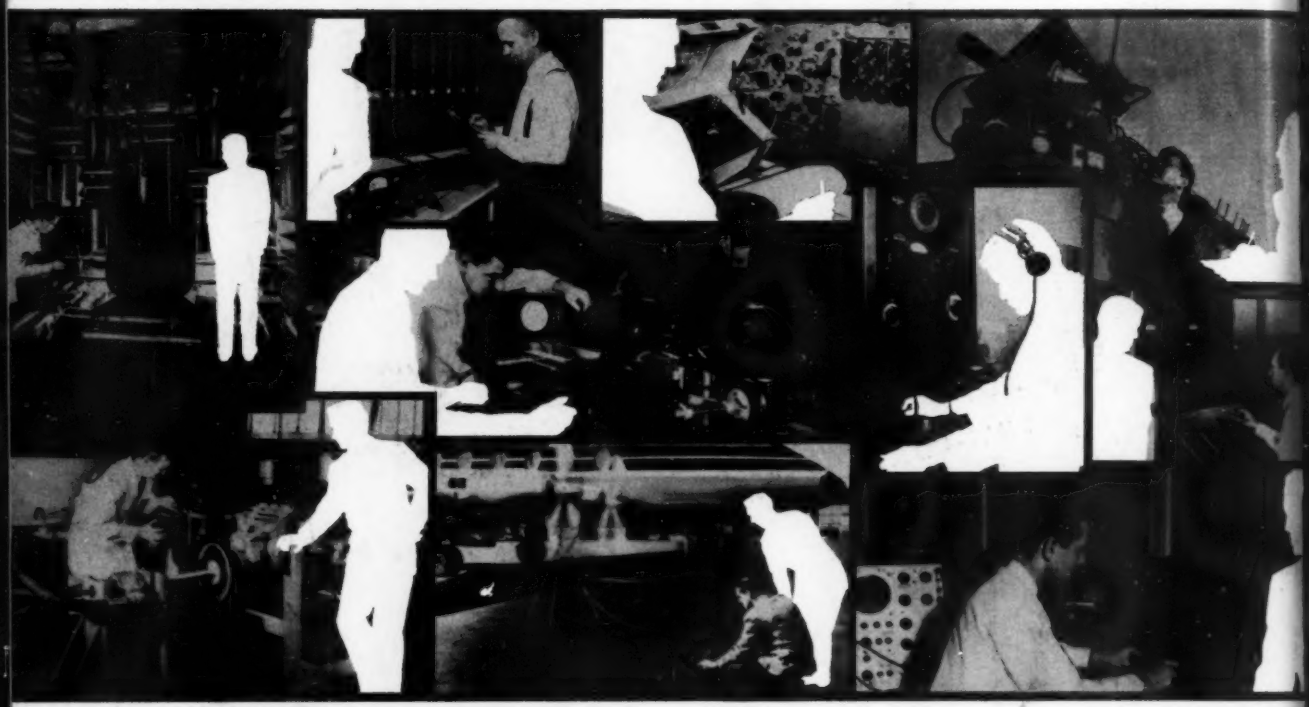

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